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REDESCRIPTION OF *TRIMERESURUS HUTTONI* SMITH, 1949 (SERPENTES, CROTALINAE), WITH A DISCUSSION OF ITS RELATIONSHIPS

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(with three text-figures)

ABSTRACT. - The Indian pit viper *Trimeresurus huttoni* Smith, 1949 is known from two specimens. The holotype is redescribed in detail. We suggest that the taxon *huttoni* is not related to other Indian species, but its colour, scalation and morphology agree with the characters of the Indo-Malayan genus *Tropidolaemus*. Consequently, it is here referred to the genus *Tropidolaemus*. The great similarities between *Trimeresurus huttoni* and *Tropidolaemus wagleri* are discussed.

KEY WORDS. - *Trimeresurus huttoni*, *Tropidolaemus*, Crotalinae, India, taxonomy.

INTRODUCTION

The *Trimeresurus*-complex is currently composed of five genera (*Trimeresurus*, *Ermia*, *Ovophis*, *Protobothrops* and *Tropidolaemus*) totalling 43 species (David and Ineich, 1998). The group is widely distributed in tropical and subtropical parts of southern, eastern, and south-eastern Asia as far east as Timor Island. On the western border of the *Trimeresurus* complex range, 15 species are currently known from India, of which no fewer than seven are endemic. Four inhabit the Andaman and Nicobar archipelago (two species are endemic to these islands); six are present only in the Himalayan region and north east India; the remaining five (all endemic) inhabit the Western and Eastern Ghats and hills of southern peninsular India.

The most poorly known Indian species is undoubtedly *Trimeresurus huttoni*, described by Malcolm A. Smith (1949) from two juveniles collected by Mr. Angus F. Hutton in the High Wavy Mountains (see below), a small mountain range south-east of Madurai, State of Tamil Nadu, southern India. This species has been mentioned in several checklists of venomous snakes (Klemmer, 1963; Minton et al., 1966; Leviton, 1968; Burger, 1971; Harding and Welch, 1980; Hoge and Romano Hoge, 1981; Welch, 1988; Toriba, 1993), but its status has not been discussed. *T. huttoni* re-

ceived little attention from Indian herpetologists. It is cited, without comments, by Murthy (1985, 1990a, 1990b, 1994) and Das (1994, 1996), but it is overlooked by Brattstrom (1964), Whitaker (1978), Deoras (1981) and Mahendra (1984). Besides the original description, data on this species can be found only in Hutton (1949), in a paper on animals from the Madurai region. *Trimeresurus huttoni* has not previously been illustrated, nor, as far as we know, rediscovered since the collection of the two original specimens.

This species ranks as one of the rarest Asian pit vipers, and its relationships were never discussed, except rather superficially by Smith (1949). It is interesting to note that the head of the holotype of *Trimeresurus huttoni* was still largely covered with red laterite. Obviously, this specimen has received little attention since its discovery. It is fortunately very well preserved and seems to have retained both its original colours and pattern.

The new taxon is mentioned in Hutton (1949: 460) as a new species. Although the scientific name and ecological data are given, no description is made, therefore the name appearing in Hutton (1949) is a *nomen nudum*. Later, in the same issue of the *Journal of the Bombay Natural History Society*, Smith (1949: 596) gives a formal description based on the two known speci-

mens. It is rather short, and we quote below, in full, the description of the holotype:

"Snout sharp, distinctly upturned, its edge continuous with the equally sharp canthus rostralis. Upper head scales unequal subimbricate, some of them obtusely keeled, 10 or 11 in a line between the supraoculars; these are narrow and entire but have their inner margins indented by the adjacent scales; internasals not twice as large as the adjacent scales, separated from one another by two small scales; supralabials, first entirely separated from the nasal, the third much larger than the others; temporals strongly keeled. Scales in 21: 23: 19 rows, indistinctly keeled on the posterior part of the body. Ventrals 146; anal entire; subcaudals 52 pairs".

"Green above, paler on the sides, with a distinct series of dorso-lateral, paired, small, white spots; pale green below; a white temporal streak, edge with red below; it is continued forwards in front of the eye; tip of snout and end of tail dull red".

"Total length 138, tail 40 mm."

According to the author, the paratype agrees well with the holotype, the differences being the separation of the internasals by a single scale, the presence of 8 scales between the supraoculars (= intersupraoculars), and the numbers of ventrals and subcaudals, respectively 139 and 49.

Smith (1949) did not discuss the relationships of his new species with other members of the *Trimeresurus*-complex, but just noted that the sharp upturned snout gave it a resemblance with *Trimeresurus borneensis*, whereas by its scalation it is related to *Trimeresurus erythrurus*, except for the separation of the first labial from the nasal.

Within the framework of a long-term systematic study of the *Trimeresurus*-complex, we examined types and specimens of most species. In the case of the present species, it is obvious that the original description is very incomplete, and that *Trimeresurus huttoni* shows unusual features for a member of the genus *Trimeresurus* sensu stricto. We therefore redescribe the holotype, and examine its relationships by comparing it with other species of the group.

MATERIALS AND METHODS

The holotype of *Trimeresurus huttoni* (BMNH 1948.1.8.75) was examined for its external features of colouration and morphological and meristic characters. It is here fully redescribed. No attempt was made to obtain data on its skull because of the uniqueness of this specimen. We did not study the paratype that Smith (1949) mentioned as being deposited in Hutton's private collection, which is now in the collection of the Bombay Natural History Society (BNHM), according to Angus Hutton (in litt., 1997).

We compared 23 characters of *Trimeresurus huttoni* with those of 12 species of the *Trimeresurus*-complex, namely those known to occur in southern India, plus a selection of other species known to have a green dorsal colour either in juveniles or adults. The morphology and scalation of *T. huttoni* was also compared in detail with those of specimens of *Tropidolaemus wagleri* from four regions.

The number of ventrals was counted according to Dowling (1951). We did not include the terminal scute in the number of subcaudals. The numbers of dorsal scale rows was counted, respectively, at one head length behind the head, at midbody (at the level of ventral corresponding to one-half the total number of ventrals), and at one head length before vent. Head scalation nomenclature follows Peters (1964).

The list of specimens examined is given in Appendix I. Museum acronyms follow Leviton et al. (1985):

BMNH: British Museum (Natural History), at present, The Natural History Museum, London; BNHM: Bombay Natural History Society, Mumbai; MNHN: Muséum National d'Histoire Naturelle, Paris; NMW: Naturhistorisches Museum, Wien; TNRC: Thai National Reference Collection, Bangkok; SMF: Natur-Museum und Forschungs-Institut Senckenberg, Frankfurt am Main; SMNH: Shanghai Museum of Natural History, Shanghai.

REDESCRIPTION OF THE HOLOTYPE OF *TRIMERESURUS HUTTONI*

(Figs. 1-3)

Body moderately stout, cylindrical; head rather short and wide at its base, about 1.6 times longer

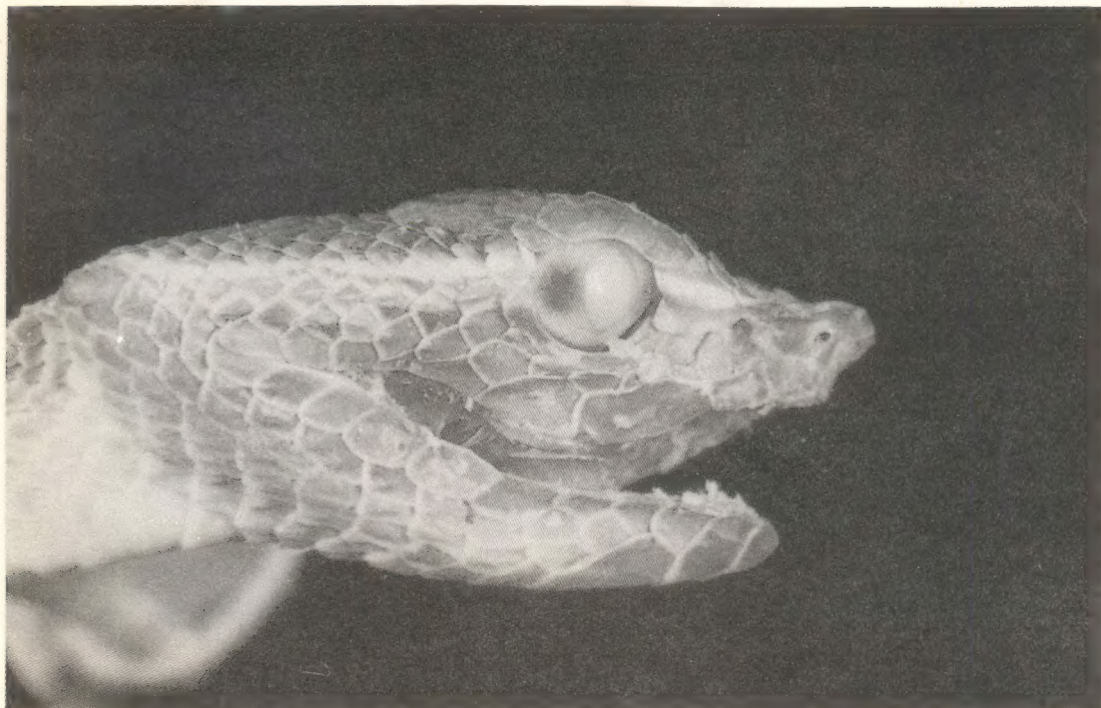


FIGURE 1: Lateral view of head of holotype of *Trimeresurus huttoni* (BMNH 1948.1.8.75).

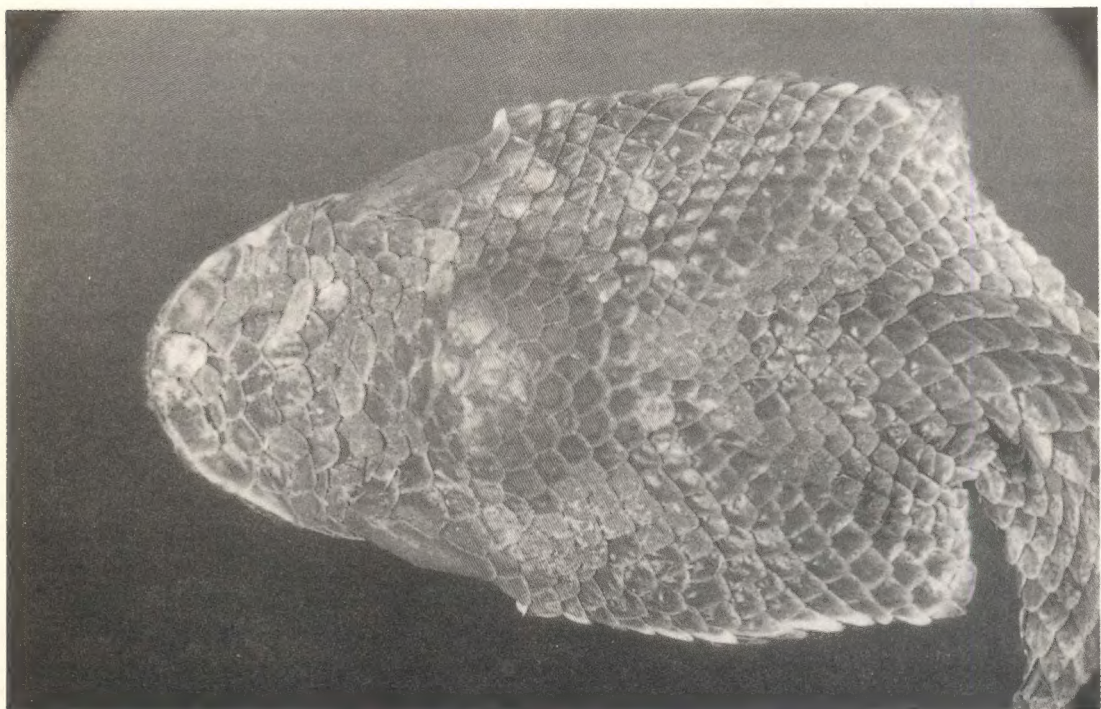


FIGURE 2: Dorsal view of head of holotype of *Trimeresurus huttoni* (BMNH 1948.1.8.75).

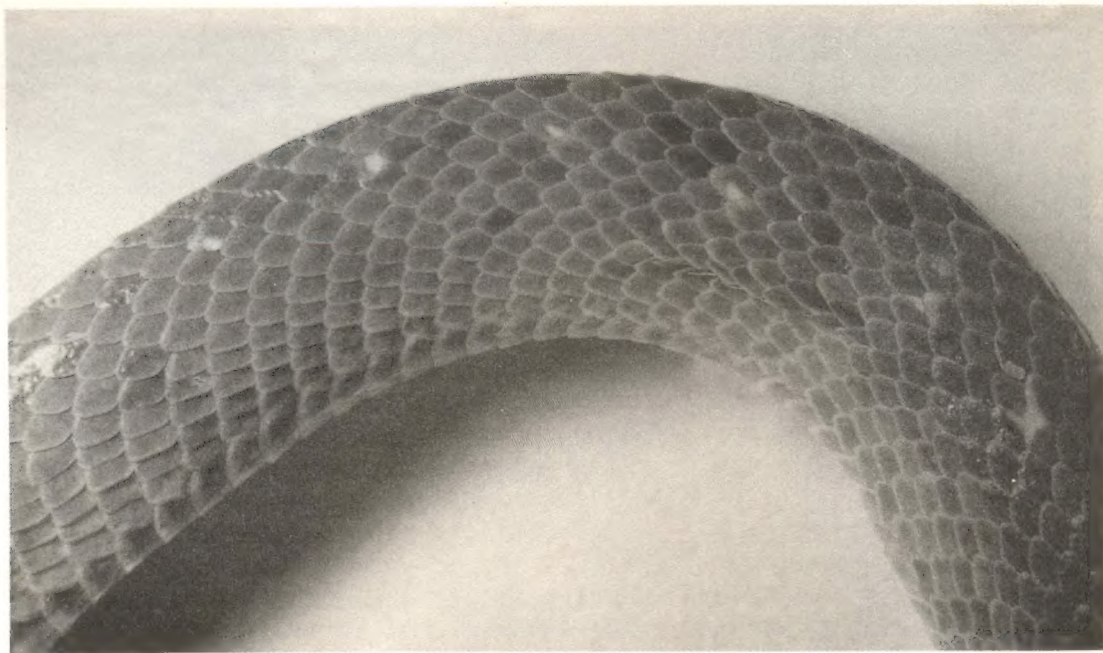


FIGURE 3: Dorsal view at midbody of holotype of *Trimeresurus huttoni* (BMNH 1948.1.8.75).

than wide, triangular, clearly distinct from neck, thick, slightly rounded medially but flattened in front of the eye and depressed in the middle of the snout; snout short, about twice as long as the diameter of the eye, slightly protracted, flattened, its tip only just slightly raised compared with its depressed, concave middle part, rounded and narrow when seen from above, angular and slightly prominent when seen from the side, with a sharp canthus rostralis; eye large (juvenile), diameter similar to the distance between its lower margin and upper lip edge; ratio of nostril-loreal pit distance/nostril-eye distance 0.61 (mean value of each side); tail cylindrical, very long and tapering, prehensile.

Snout-vent length (SVL): 98 mm, tail length (tL): 38 mm; total length (TL): 136 mm.

tL / TL ratio: 0.28.

Ventrals: 146; subcaudals: 52 pairs + one terminal scale; anal entire.

Dorsal scales: 25 [not 21 as written by Smith]-23-19, rhombic and smooth at midbody, some feebly keeled on the posterior part of body.

Rostral as high as wide, triangular, barely visible from above, nasal triangular, undivided, with nostril in its middle; no nasal pore visible;

1 pair of narrow enlarged, internasals, about twice as long but barely wider than adjacent scales on upper snout surface, separated from one another by 1 (not 2 as mentioned in the original description) small scales that are about half as wide as the internasals; 4 subequal canthal scales bordering the canthus rostralis between the internasal and the corresponding supraocular, slightly enlarged compared with adjacent snout scales; 1 small triangular loreal; 2 upper preoculars above the loreal pit, the lower one bordering the upper margin of the loreal pit, the upper one visible from above, both elongated and in contact with the loreal; the lower preocular that normally borders the lower margin of the loreal pit is divided into two small scales; 2 postoculars; 1 supraocular, entire, long and narrow, barely larger than the adjacent dorsal head scales and narrower than internasals, largely indented on its inner margin; dorsal snout and cephalic scales relatively large, irregular and unequal, juxtaposed or barely imbricate, flat, distinctly keeled both on the snout and on the middle and posterior part of the head, more keeled and rather imbricate on posterior part of head; 9 intersupraoculars; temporals in three rows, the lower ones enlarged, as large as

the supralabials, all strongly keeled; 1 thin, elongated, crescent-like subocular; 9 supralabials on each side, the third being the largest; 1st supralabial completely separated from the nasal; 2nd not bordering the anterior margin of the loreal pit and bordered above by a prefoveal that lines the whole of the anterior margin of the loreal pit, one granular scale on each side between the nasal and the 2nd supralabial; 3rd supralabial large, rather low and elongated, about 2.3 times as long as high, separated both from the posterior lower preocular scale and from the subocular by one small scale; 4th supralabial nearly as high and long as the third, separated from the subocular by 1 small scale; 5th and succeeding posterior supralabials much smaller than preceding ones, not larger than lower temporals but smooth; 5th supralabial separated from the subocular by two scale rows and in contact with the first and second lower temporals; 10 pairs of infralabials, those of the first pair in contact with each other and obtusely but distinctly keeled, infralabials of the first, second and third pairs in contact with the chin shield; one pair of elongated, keeled chin shields; 7 rows of gular scales, distinctly keeled.

In preservative, dorsal body and tail surfaces dull green, slightly paler on the sides of the body, with a series of small, vertically elongated white spots located on each side of the 2nd and 3rd scale rows from the vertebral row, separated from each other by about 3-5 scales; no ventrolateral stripes; pale green below; end of tail dull reddish-brown for a length equivalent to the 25 posterior subcaudal scales.

Head dull green above and on its sides; a white postocular streak on the 3rd and 4th rows of temporals from eye to the neck, edged below with a dull, discoloured, rather indistinct red streak; a preocular white streak running forward in front of the eye, on the upper preocular and loreal, vanishing on this latter scale and not reaching the nasal; this anterior white streak is bordered below with a reddish, indistinct streak that makes the snout tip reddish.

RESULTS AND DISCUSSION

Our interest in the *Trimeresurus* complex led us to examine more than 300 specimens of nearly

all species of these Asian pit vipers, including the name-bearing types of most valid species. It appeared immediately and totally unexpectedly that, from our study of the holotype, this specimen shows a striking similarity in habitus and colouration to juveniles of *Tropidolaemus wagleri*. In the latter species, juveniles have a characteristic overall green colouration (even if adult animals typically become yellow and black) with red or white spots on the dorsum or vertical bars on the flanks, and a pre- and postocular bicolour streak. Furthermore, these similarities in pattern between *huttoni* and *Tropidolaemus wagleri* are supported by largely identical morphological and meristical characters, namely a second supralabial not bordering the loreal pit and the strongly keeled dorsal head and gular scales.

The genus *Tropidolaemus* Wagler, 1830 was resurrected as a subgenus of *Trimeresurus* by Brattstrom (1964), and considered to be a distinct genus by Burger (1971) on the basis of both anatomical and external features. This genus is currently monospecific, including the sole species *Tropidolaemus wagleri* Wagler, 1830 (see David and Vogel, 1996 and David and Ineich, 1998). According to Brattstrom (1964), the genus *Tropidolaemus* is defined as follows:

"Top of head with numerous small scales of varying size, including many or several in the frontal area. All scales on top of head usually keeled; gular scales keeled. Nasal pore absent. Subcaudals in one or two rows. Pterygoid teeth extending posteriorly past middle of junction of ectopterygoid with pterygoid. Ectopterygoid longer than basal portion of pterygoid. Palatine low, not humped or forked. Frontals with centers depressed. Lower lumen of fang medial. Prefrontals laterally wider than long. Curvature of pit cavity interrupted by a small process or knob. Venom neurotoxic. Color primarily green. Arbo-real." (verbatim from Brattstrom, 1964: 251).

Tropidolaemus wagleri is a wide ranging and often common species that occurs from southern Thailand south to Sumatra, then eastwards through Borneo and the Philippine Islands to Sulawesi (David and Ineich, 1998). Several colour morphs are known in this species, some of them seemingly correlated with range. We con-

TABLE 1: Comparison of morphological data and body scalation in pit vipers (genera *Tropidolaemus*, *Trimeresurus* and *Protobothrops*). Abbreviations: Obs: Overall body colour bright green in life: + yes, - no. - Bws: white and red dorsolateral vertical bars or dorsolateral spots on body: + present, - absent. - Prs: preocular streak: + present, - absent. - Pos: postocular streak: + present, - absent. - Cps: colour of the postocular streak: - absent, 1 black or dark brown, 2 white, 3 white plus reddish-brown or orange, 4 yellow plus black. - tL/TL: ratio tail length/total body length (range). - Npo: presence of a nasal pore: + present, - absent. - Ven: number of ventrals (range). - Sc: number of subcaudals (range). - Co (m): number of dorsal scale rows at midbody. - KCo: dorsal scale rows at midbody keeled: ++ strongly keeled, + weakly keeled, - smooth. Sources of comparative data listed with Table 2.

| TAXON | Obs | Bws | Prs | Pos | Cps | tL/TL | Npo | Ven | Sc | Co (m) | KCo |
|-------------------------------------|------------|------------|-----|-----|-------|-----------|-----|---------|-------|------------|------|
| <i>Tropidolaemus huttoni</i> | + | + | + | + | 3 | 0.28 | - | 139-146 | 49-52 | 23 | -/+ |
| <i>Tropidolaemus wagleri</i> | -/+ (a) | +/- (a) | + | + | 1-4 | 0.14-0.19 | - | 127-154 | 45-56 | 21-27 | +;++ |
| <i>Trimeresurus gramineus</i> | + | - | - | +/- | 1 | 0.16-0.18 | + | 145-177 | 55-71 | 21 | -/+ |
| <i>Trimeresurus labialis</i> | - | - | - | -/+ | 0/2 | 0.13-0.19 | + | 154-174 | 46-65 | 21-23 | -/+ |
| <i>Trimeresurus macrolepis</i> | + | - | - | -/+ | 0/1 | 0.15-0.23 | + | 133-144 | 44-56 | 12-16 | +;++ |
| <i>Trimeresurus malabaricus</i> | -/+ | - | - | -/+ | 0/1 | 0.15-0.18 | + | 136-159 | 44-63 | (19) 21-23 | +;++ |
| <i>Protobothrops strigatus</i> | - | - | - | -/+ | 0/1 | 0.12-0.16 | + | 128-150 | 32-52 | 21 (23) | -/+ |
| <i>Trimeresurus trigonocephalus</i> | + | - | - | + | 1 | 0.15-0.17 | + | 142-170 | 53-69 | (17)-19 | -/+ |
| <i>Trimeresurus albolabris</i> | + | - | - | - | - | 0.14-0.21 | + | 149-173 | 48-78 | 21 (23) | +;++ |
| <i>Trimeresurus erythrurus</i> | + | - | - | - | - | 0.15-0.21 | + | 151-180 | 49-79 | (21) 23-25 | + |
| <i>Trimeresurus hageni</i> | + | -(b) | - | + | 2 | — | + | 177-198 | 63-85 | 21 | + |
| <i>Trimeresurus stejnegeri</i> (c) | + | -(d) | - | -/+ | 0-2/3 | 0.17-0.22 | + | 150-172 | 59-77 | 21 | + |

Additional notes.-

(a). - Juvenile specimens, from all populations, and most adult males are bright green. The preocular bicolour streak, and the rows of white or white and reddish-brown vertebral spots or short vertical bars occurs typically in green specimens. In the typical form from Thailand and Malaya, the preocular streak (yellow) is difficult to distinguish from the snout pattern.

(b). - Large, rounded, white or pinkish-white dorsolateral spots are present.

(c). - There could be several undescribed species under this name; we give data for the nominal species *stejnegeri* sensu lato.

(d). - Sometimes white vertebral spots, but not dorsolateral dots as in *huttoni* and *wagleri*.

sider the systematics of this species to be still unresolved (see below for a discussion). Leviton (1964) considered *Tropidolaemus wagleri* a monotypic species, an interpretation followed by most subsequent authors. We retain it here, although it seems quite unsatisfactory. However, it appears that juveniles from all populations exhibit nearly identical colouration and pattern,

typically bright green with one row of small white or white and small red spots on each side of the upper parts of the body, or short vertical white or red bars on the flank, a loreal and temporal bicoloured streak, and a reddish tail tip.

We compared only external features of *Trimeresurus huttoni* with those of (1) *Tropidolaemus wagleri* (juveniles and adults),

TABLE 2: Comparison of head scalation and other features in pit vipers (genera *Tropidolaemus*, *Trimeresurus* and *Protothrops*). Abbreviations: SpL: number of supralabials (range). - Ssn: separation of the 1st supralabial with the corresponding nasal: + yes, both scales totally differentiated, - no, both scales partly separated by a shallow furrow or totally fused. - CSP: contact of the second supralabial with the loreal pit: + yes, - no. CSob: number of the supralabial(s) that are in contact with the subocular. Is: number of intersupraoculars between the supraoculars (range). Kus: strong keels on upper snout scales: + yes, - no. Kuh: keels on upper head scales: ++ strongly keeled, + weakly keeled, - no. Kte: keels on temporals scales: ++ strongly keeled, + weakly keeled, - absent. InL: number of infralabials. CIn: first pair of infralabials in contact: + yes, - no. Klh: keels on gular and chin scales: ++ strongly keeled, + weakly keeled, - absent.

| TAXON | SpL | Ssn | CSP | Is. | CSob | Kus | Kuh | Kte | InL | CIn | Klh |
|-------------------------------------|-------|-----|-----|-------|---------------|-----|------|-----|-------|-----|-----|
| <i>Tropidolaemus huttoni</i> | 9 | + | - | 8-9 | 0 | + | + | + | 10 | + | + |
| <i>Tropidolaemus wagleri</i> | 8-10 | + | - | 10-17 | 0 | + | + | + | 10-13 | + | + |
| <i>Trimeresurus gramineus</i> | 10-12 | + | + | 8-11 | 0 | - | - | - | 9-10 | + | - |
| <i>Trimeresurus labialis</i> | 9-12 | - | + | 8-11 | Nr 3 or 3 & 4 | - | - | - | 11-16 | + | - |
| <i>Trimeresurus macrolepis</i> | 7-9 | + | -/+ | 3 | Nr 3 or 3 & 4 | - | - | - | 10-12 | + | - |
| <i>Trimeresurus malabaricus</i> | 8-10 | + | + | 7-9 | 0 | - | - | -/+ | 10-13 | + | - |
| <i>Protothrops strigatus</i> | 8-10 | + | - | 8-11 | 0 | - | - | - | 9-12 | + | - |
| <i>Trimeresurus trigonocephalus</i> | 9-11 | + | + | 2-6 | Nr 3 & 4 | - | - | -/+ | 12 | + | - |
| <i>Trimeresurus albolabris</i> | 7-13 | - | + | 8-14 | 0 or Nr 3 | - | - | -/+ | 11-16 | + | - |
| <i>Trimeresurus erythrurus</i> | 9-13 | - | + | 10-15 | 0 | 0 | 0/++ | + | 12-14 | + | 0 |
| <i>Trimeresurus hageni</i> | 9-11 | + | + | 4-8 | Nr 3 | 0 | 0 | 0 | 13 | + | 0 |
| <i>Trimeresurus stejnegeri</i> (b) | 9-12 | + | + | 9-13 | 0 or Nr 3 | 0 | 0/+ | 0/+ | 11-15 | + | 0 |

Sources:

Tropidolaemus wagleri: Boulenger (1896); Leviton (1964); De Rooij (1917); Tweedie (1983). - 24 specimens
Trimeresurus trigonocephalus: Wall (1921); Smith (1943); Deřaniyagala (1955); A. De Silva (1990a, 1990b); P. H. D. H. De Silva (1980). - 2 specimens.
T. gramineus: Mahendra (1984); Murthy (1990a, 1990b); Pope and Pope (1933); Regenass and Kramer (1981); Smith (1943); WALL (1919).
T. labialis: Mahendra (1984); Murthy (1990b); Smith (1943); Werner (1926). - 6 specimens.
T. macrolepis: Boulenger (1896); Mahendra (1984); Murthy (1990a, 1990c); Smith (1943). - 6 specimens.
T. malabaricus: Mahendra (1984); Murthy (1990a, 1990b); Rao (1917); Smith (1943). - 4 specimens.
Protothrops strigatus: Boulenger (1896); Mahendra (1984); Murthy (1990a, 1990b); Smith (1943). - 4 specimens.
Trimeresurus albolabris: Pope and Pope (1933); Regenass and Kramer (1981); Smith (1943). - 10 specimens.
T. erythrurus: Pope and Pope (1933); Regenass and Kramer (1981); Smith (1943); Toriba et al. (1990). - 2 specimens.
T. hageni: Tweedie (1983). - 1 specimen.
T. stejnegeri: Pope and Pope (1933); Smith (1943); Regenass and Kramer (1981). - 12 specimens.

TABLE 3: Comparisons between *Tropidolaemus huttoni* and *T. wagleri*. Abbreviations: n: number of specimens examined. Obs: Overall body colour bright green: + yes, - no. Bws: white vertical stripes or dots on body: + present, - absent. Cps: colour of the postocular streak: 1 black, 2 white, 3 reddish-brown + white, 4 yellow + white. tL/TL: tail length/total body length ratio (range). Ven: number of ventrals plates. Sc: number of subcaudals. Co: number of dorsal scale rows at midbody. KCo: carination of dorsal scales at midbody: ++ strongly keeled, + keeled, - smooth. SpL: number of supralabials (left/right). Cep: number of cephalic scales between the supraoculars (range). InL: number of infralabials (range).

| Population | Obs | Bws | Cps | tL/TL | Ven | Sc | Co | KCo | SpL | Cep | InL |
|---|-----|-----|-------|-----------|---------|-------|-------|-------|------|-------|-------|
| <i>Trop. huttoni</i> | + | + | 3 | 0.28 | 139-146 | 49-52 | 23 | -/+ | 9 | 8-9 | 10 |
| <i>Trop. wagleri</i> (literature data for the whole range) | -/+ | -/+ | 1-4 | 0.14-0.19 | 127-154 | 45-56 | 21-27 | + /++ | 8-10 | 10-17 | 10-13 |
| Thailand/Malay adults (n = 4) | -/+ | -/+ | 3/4 | 0.14-0.17 | 134-141 | 49-54 | 25 | + | 9-10 | 13-17 | 11-13 |
| juveniles (n = 1) | - | - | 4 | 0.14-0.17 | 134-141 | 49-54 | 25 | + | 9-10 | 13-17 | 11-13 |
| Java/Sumatra adults (n = 4) | + | + | 3 | — | — | — | — | + | — | — | — |
| juveniles (n = 2) | -/+ | -/+ | 1/2/4 | 0.15-0.19 | 135-138 | 45-55 | 23-25 | + /++ | 9-10 | 12-15 | 11-13 |
| Borneo adults (n = 6) | - | - | 4 | 0.15-0.17 | 137-138 | 45-52 | 25 | + | 9-10 | 12-15 | 11-13 |
| juveniles (n = 2) | + | + | 1/2 | 0.18-0.19 | 135 | 54-55 | 23 | + | 10 | 12 | 11 |
| Philippine Is. adults (n = 5) | -/+ | -/+ | 1/3 | 0.14-0.18 | 130-142 | 46-53 | 21-27 | + | 9-10 | 10-13 | 10-12 |
| juveniles (n = 1) | - | -/+ | 1/3 | 0.14-0.18 | 130-142 | 46-53 | 21-27 | + | 9-10 | 10-13 | 10-11 |
| Philippine Is. adults (n = 5) | + | + | 3 | 0.15 | 140 | 48 | 21 | + | 9-10 | 13 | 12 |
| Philippine Is. adults (n = 5) | + | -/+ | 1/3 | 0.14-0.16 | 127-137 | 45-50 | 23-25 | + /++ | 9-10 | 12-16 | 10-11 |
| adults (n = 5) | + | -/+ | 1/3 | 0.14-0.16 | 127-137 | 45-50 | 23-25 | + /++ | 9-10 | 12-16 | 10-11 |

(2) all south Indian and Sri Lankan taxa (*Trimeresurus gramineus*, *T. macrolepis*, *T. malabaricus*, *T. trigonocephalus*, plus *T. labialis* from the Andaman Islands, and the taxon *strigatus*, recently tentatively placed in the genus *Protothrops* [Kraus et al., 1996]), and (3) a selection of green *Trimeresurus* species covering each of the groups recognised by Brattstrom (1964: 244). Among these taxa, we selected *T. albolabris albolabris*, *T. erythrurus*, *T. hageni* (a taxon not mentioned by Brattstrom but closely related to *T. sumatranus*) and *T. stejnegeri*. Results are given in Tables 1-2.

Data were taken from an examination of preserved specimens and from the literature (see Table 2) for general meristic data such as number of ventrals, subcaudals and supralabials, and from an examination of preserved specimens for supplementary meristic data and specific characters or data not found in literature. We retained 23 characters that may be considered to be diagnostic in the *Trimeresurus*-complex, bearing respectively on body colouration, morphology and body

scalation (Table 1) and head scalation (Table 2). These characters are as follows:

Colouration: Overall body colouration; presence of white stripes or dots on body; presence of a preocular streak; presence of a postocular streak; colour of the postocular streak.

Morphology: Ratio tail length/total body length (limits of range and mean value); presence of a nasal pore; separation of the 1st supralabial from the corresponding nasal; contact of the second supralabial with the loreal pit; presence of keels on upper snout scales; presence of keels on upper head scales; presence of keels on temporals; first pair of infralabials in contact or not; presence of keels on gular and chin scales.

Meristic characters: Number of ventrals; number of subcaudals; number of dorsal scale rows at midbody; number of supralabials; number and shape of loreal(s); intersupraoculars; number of supralabial(s) in contact with the subocular; number of infralabials.

It results from these data that the nominal taxon *huttoni* differs by the combination of six major, diagnostic generic characters (2nd su-

pralabial not bordering the loreal pit, scales keeled on snout, upper head and chin, presence of a preocular streak, dorsolateral white and red spots) from all other members of the *Trimeresurus*-complex with the exception of *Tropidolaemus wagleri*, with which it shares all these characters, at least in the juveniles and the green adult specimens. We examined specimens from more species of the *Trimeresurus*-complex than those here mentioned above for our comparison, and all of them also largely differ from *huttoni*.

The strong morphological similarities between the taxon *huttoni* and *Tropidolaemus wagleri* were thoroughly examined. The question was a possible conspecificity between these taxa. We give in Table 3 a detailed comparison of selected morphological and meristic data between *huttoni* and specimens of *Tropidolaemus wagleri* from several populations. Diagnostic generic characters that are not repeated in this table are: the lack of a nasal pore, the dorsal snout scales, upper head scales and gular scales keeled, the supralabials not in contact with the subocular and the keeled temporals. In this table, specimens regarded as juveniles have a total length below 300 mm.

Because of the presence in the holotype of *Trimeresurus huttoni* of all external generic diagnostic characters of the genus *Tropidolaemus*, we here refer this nominal taxon to the genus *Tropidolaemus* Wagler, 1830. However, the very long tail in *huttoni* and its geographical isolation lead us to regard *huttoni* as specifically distinct from *Tropidolaemus wagleri*. We therefore propose the following new combination:

***Tropidolaemus huttoni* (Smith, 1949)
new combination**

"*Trimeresurus huttoni*" Hutton, 1949: 460.
Nomen nudum, no description.

Trimeresurus huttoni Smith, 1949: 596. - Type locality.- "The High Wavy Mountains, Madura District, South India; altitude 5,200 feet", now a plateau in the western central edge of the Varushanad Hills, just east of Kambam, District of Madurai, State of Tamil Nadu, India, 1590 m. - Holotype. BMNH 1948.1.8.75, sex male; coll. Angus F. Hutton. Paratype.- Originally in the private collection of Angus Hutton

(Smith, 1949), at present BNHM 2658; sex unknown, same collector.

Trimeresurus huttoni: Klemmer, 1963: 432; Minton et al., 1966: 118; Leviton, 1968: 566; Burger, 1971: 31; Harding and Welch, 1980: 73; Hoge and Romano Hoge, 1981: 259; Regenass and Kramer, 1981: 165; Murthy, 1985: 69, 1986: 83, 1990a: 63, 1990b: 83, 1994: 35; Welch, 1988: 137, 1994: 115; Toriba, 1993: 100; Murthy et al., 1993: 139; Das, 1994: 38, 1996: 62.

Diagnosis. - A pit viper endemic to southern peninsular India characterised by the absence of a nasal pore, an elongated snout, slightly raised at its tip, upper surface of snout and head covered with small, distinct keels, strongly keeled gular scales, second supralabial not bordering the anterior margin of the loreal pit and bordered above by a prefoveal, a tail length/total length ratio of at least 0.28, green colouration in juveniles, and white and red pre- and postocular streaks.

Variations. - Only two specimens are known. The currently reported variation is: ventrals 139-146; subcaudals 49-52; 8-9 intersupraoculars (Smith, 1949).

Range. - India: State of Tamil Nadu: western Varushanad Hills (in the High Wavy Mountain Range). Known only from the type locality.

The High Wavy Mountains are located just east from the city of Kambam, from where its summit and a waterfall can be seen when looking towards the east (Blatter and Hallberg, 1917). In general, they correspond to an elevated plateau in the centre of the western edge of the Varushanad Hills, at about 09°30'N, 77°30'E. Bates and Harrison (1997), in their gazetteer, gave the coordinates for the High Wavy as 09° 50'N; 77° 26'E. According to Angus Hutton (pers. comm., 1997), the locality of capture was around coordinates 09°36'N, 77°15'E. The High Wavy Mountains are currently owned by a private tea estate.

Blatter and Hallberg (1917) and Hutton (1949) described the High Wavy Mountains as an undulating plateau, approximately 17 square miles (ca. 44 square km), with an average elevation of about 1,500 m (ca. 5,100 ft), that rises steeply from the surrounding plains. The highest point of the plateau, Brooks Peak, is over 1,950 m (ca. 6,100 ft). The wet montane evergreen forest begins at an elevation of 1,200 m. Lower

elevations are covered with grasslands and light deciduous forests, and do not support the evergreen forest suitable for species restricted to primary montane wet forests. According to Hutton's description, only a small area of the plateau was cultivated at that time.

Biological data. - Both types were collected at an elevation of 1590 m in an evergreen wet montane forest. These animals were discovered from beneath leaves of a hill bamboo (*Ochlandra travancorica*) clump, a plant locally known as "Eeta" in Tamil. The diet and other aspects of its biology are unknown.

TAXONOMIC IMPLICATIONS

This new combination modifies the content of the genus *Tropidolaemus*, which, however, still remains uncertain. *Tropidolaemus huttoni*, as currently known, can be separated from juvenile *T. wagleri* only by the much higher tail length/total length ratio in *T. huttoni* (0.28) than in *T. wagleri* (0.14-0.19) and by its geographic range. Otherwise, the holotype of *huttoni* is similar to juveniles of *wagleri* of equivalent size.

The current subspecific systematics of the wide ranging species *Tropidolaemus wagleri* is not resolved. Three subspecies were recognised by Taylor (1922a: 298): *Tropidolaemus wagleri wagleri* Wagler, 1830, *T. wagleri alboviridis* (Taylor, 1917) and *T. wagleri subannulatus* (Gray, 1842), the latter two being endemic to the Philippine Islands. Leviton (1964) considered *Tropidolaemus wagleri* to be a monotypic species, and this arrangement has been followed by subsequent authors. However, there are positive relationships between colour morphs and geographical range, and it is possible that some insular populations deserve a subspecific status.

The status of *Trimeresurus philippinensis* Gray, 1842 (Gray, 1842: 48; type locality: Philippine Islands), regarded as valid by Taylor (1922) and Maslin (1942) as *Trimeresurus philippinensis*, is not resolved either. It was placed in the synonymy of *Trimeresurus wagleri* (now *Tropidolaemus wagleri*) by Leviton (1964: 266), who, however, apparently did not examine its holotype. We examined the holotype of *Trimeresurus philippinensis* (BMNH 1946.1.1767) and another specimen (MNHN 4064, Paris; holotype of

Tropidolaemus hombroni Guichenot in: Dumont d'Urville, 1848). Both specimens display external features diagnostic of the genus *Tropidolaemus*. Compared with *Tropidolaemus wagleri* both specimens from the Philippine Islands display notable differences in the morphology of the head, in the scalation of head and body, and in colouration. They may belong to a valid species, distinct from *Tropidolaemus wagleri*, for which the name *Tropidolaemus philippinensis* is available. The problem will be addressed in a later paper. We therefore take a conservative approach, and for now, retain only two species in the genus *Tropidolaemus*.

Tropidolaemus Wagler, 1830

Tropidolaemus Wagler, 1830: 175.

Type species. - *Tropidolaemus wagleri* Wagler, 1830, by monotypy.

Diagnosis. - A genus of Asian Crotalinae characterised by the absence of a nasal pore, and by the upper surface of the snout and head covered with distinctly keeled small scales, strongly keeled gular scales, the second supralabial not bordering the anterior margin of the loreal pit and bordered above by a prefoveal, green colouration in juveniles, and the presence of a white and red pre- and postocular streak.

Relationships. - Long regarded as a synonym or a subgenus of *Trimeresurus* (Brattstrom, 1964), the genus *Tropidolaemus* was resurrected by Burger (1971) to accommodate the species formerly referred to *Trimeresurus wagleri*. This interpretation was confirmed by phylogenetic analysis based on immunological data and mitochondrial DNA sequence data, which have shown that *Tropidolaemus wagleri* is only distantly related to species of *Trimeresurus* sensu stricto (Kraus et al., 1996). The distinctiveness of the genus *Tropidolaemus*, which constitute a basal lineage within the Asian crotalines, is now regarded acceptable (Cadle, 1992; Kraus et al., 1996; Vidal, unpublished).

Contents. - Two species: *Tropidolaemus huttoni*, *T. wagleri*.

Tropidolaemus huttoni (Smith, 1949)

Trimeresurus huttoni Smith, 1949: 596.

Type locality. - "The High Wavy Mountains, Madura District, South India; altitude 5,200

feet", now a plateau in the western central edge of the Varushanad Hills, Madurai District, State of Tamil Nadu, India, 1590 m.

Comments. - This species is monotypic.

Diagnosis. - A species endemic to southern India characterised by a tail length/total length ratio of 28%.

Range. - India (State of Tamil Nadu).

***Tropidolaemus wagleri* Wagler, 1830**

[*Tropidolaemus*] *wagleri* Wagler, 1830: 175.

Type locality. - Asia.

Comments. - We refer the reader to David and Vogel (1996) for a discussion about the authorship of this species, previously credited to Boie (1827) or Schlegel (1837). This species is monotypic (see above).

Diagnosis. - A species of the genus *Tropidolaemus* found in south-eastern Asia and Indonesia characterised by a tail length/total length ratio less than 20%.

Range. - Brunei Darussalam; Federation of Malaysia (Peninsular Malaya and East Malaysia on Borneo Island); Indonesia (Bangka Is., Belitung Is., Butung Is., Kalimantan on Borneo Is., Karimata Is., Mentawai Archipelago, Natuna Archipelago, Nias Is., Sulawesi, Sumatra); Philippine Islands (Balabac Is., Basilan Is., Bohol Is., Dinagat Is., Jolo Is., Leyte Is., Luzon Is., Mindanao Is., Negros Is., Palawan Is., Samar Is., Siasi Is., Sibutu Is., Tawitawi Is.); Singapore; and Thailand.

ZOOGEOGRAPHICAL REMARKS

There is no possibility for an erroneous type locality of *Tropidolaemus huttoni*, and human introduction in this remote locality, once regarded as largely unexplored by Angus Hutton, may be ruled out. This generic reallocation considerably extends the range of the genus *Tropidolaemus* westwards. The previous western limit was extreme southern Thailand, from the Surat Thani Province of southern Thailand (Cox, 1991). The presence of a *Tropidolaemus* species in southern peninsular India is therefore intriguing.

There are other reptile genera that show a similar distribution, occurring in south-east Asia (Indo-China, Malaya and the Indo-Malayan Ar-

chipelago) and southern India and Sri Lanka, with an apparent absence from Myanmar and eastern and central India. According to Das (1996), there are 42 genera of Indo-Malayan reptiles represented in the Indian region. Some snake genera of southern India with Indo-Malayan affinities have been discussed by Hora and Jayaram (1949), the most striking examples being the genera *Cylindrophis* and *Chrysopelea* (ranges according to Welch, 1988). The former has a single species endemic to Sri Lanka (*C. maculatus*), seven on various islands of the Sundas and a widespread species (*C. ruffus*) that is found on both mainland (south of latitude 26° N) and insular situations, eastwards up to Sulawesi, across many of the islands of the Indo-Malayan Archipelago. The latter genus has three Indo-Malayan species and one Sri Lankan endemic, in addition to a widespread species (*Chrysopelea ornata*) with a discontinuous range, being found in eastern India to southern China, southwards to Malaya, with populations in south-western India and Sri Lanka.

These and other snake genera discussed by Hora and Jayaram (1949) share a common characteristic in being absent from the area between the Indo-Chinese region and southern peninsular India. Based on such discontinuous ranges, Hora (1937; 1949; 1953) developed the Satpura Hypothesis, which explained the phenomenon by suggesting the existence of an ancient mountain range between the Vindhya and Satpuras of north-central India, on one side, and the Garo-Khasi Hills of north-eastern India, on the other. The Indo-Malayan species could have migrated from north-eastern India towards the Western Ghats of peninsular India along these wet mountains. This hypothesis is, however, not supported by recent geological data, although Swan (1993) provided some seismographic and zoogeographical evidence in its support. On the other hand, apart from a few shared genera, Das (1996) showed that the reptile faunas of the Western Ghats and of north-eastern India are not similar, and concluded that the occurrence of Indo-Malayan elements in the fauna of southern India and Sri Lanka to be the remnants of an ancient, much wider distribution of plant and animal groups. The mesic forests on the moun-

tains of southern India were the sole refuges to many Indo-Malayan forest-dwelling elements, that are now absent from the adjacent dry lowlands. The extinction along the route is thought linked to climate change following the Eocene, when a recession of tropical evergreen forests took place, being replaced by dry savannas. Many species in the uplands, particularly those with affinities in the east, therefore are considered relicts in terms of distribution, and isolated from their close relatives much further east.

Some evidence in support of this hypothesis is provided by the known distribution pattern shown by members of the *Trimeresurus*-complex (involving the genera *Trimeresurus*, *Ermia*, *Ovophis*, *Protothrops* and *Tropidolaemus*). Species of one or more of these genera are found as far west as Nepal and northern India, but none have been recorded from central India. However, not less than six endemic species have been described from the evergreen forest-clad hills of the Western and Eastern Ghats. This is in support of the suggestion of Das (1996), of an ancient, more widespread distribution of evergreen forest species within the Indian peninsula. It is worth noting that *Tropidolaemus wagleri* is typically a lowland species, with a maximum recorded elevation of 1,300 m in Sumatra (David and Vogel, 1996), but is more usually found at much lower elevations, while its Indian congener is known only from a montane forest above 1,500 m.

The distribution pattern of *Tropidolaemus* differs notably from those involved in the Satpura Hypothesis in that the ranges of genera discussed by Hora (1953) extend much further north (Myanmar and north-eastern India) than *T. wagleri*, a conspicuous and well-known lowland species that is absent north of peninsular Thailand, and even from apparently ecologically suitable islands, lowlands and hills of southern Myanmar. This distributional disjunction is much wider than those known in genera upon which Hora based his hypothesis. A better knowledge of the distribution of *T. huttoni* through further collections would throw light on the zoogeography of the genus.

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APPENDIX I SPECIMENS EXAMINED

Protobothrops strigatus: MNHN 4061, "Hindoustan" (= India); SMF 21208, Nilgiri Hills, Tamil Nadu, India; SMF 21209/1-2, Nilgiri Hills, Tamil Nadu, India.

Trimeresurus albolabris albolabris: MNHN 1885.384, near Sisophon, Province of Aranh, Cambodia; MNHN 1980.1343-1344, Cambodia; MNHN 1989.702, Cambodia; MNHN 1897.432, Ban Taxeng, Kas' country, Laos; MNHN 1893.415-416, Bhamo, Myanmar; MNHN 1904.404-405, Province of Cao Bang, Vietnam; MNHN 1974.1350, Province of Ha Tinh, Vietnam.

Trimeresurus erythrurus: MNHN 4058, "Bengale"; SMF 73377, unknown locality.

Trimeresurus hageni: MNHN 1899.269, Malaya, Federation of Malaysia.

Trimeresurus labialis: NMW 18813:1-3, Nicobar Islands, India; NMW 14863:1-3, Nicobar Islands, India.

Trimeresurus macrolepis: MNHN 1913.3-4, Palni Hills, east of Dindigul, State of Tamil Nadu, India, 2000 m; MNHN 1946.82, India; MNHN 1948.338, India; MNHN 1948.339, India; MNHN 1948.340, India.

Trimeresurus malabaricus: MNHN 1913.5, Palni Hills, near Tiruchirapalli, State of Tamil Nadu, India; NMW 23946:1-2, Anaimallai Hills, State of Tamil Nadu, India; NMW 23945, Anaimallai Hills, State of Tamil Nadu, India.

Trimeresurus stejnegeri: MNHN 1912.352, "San Chouen Fou", Province of Guizhou, People's Republic of China; SMNH 4038, Da Jing, Mt. Jing Gang, Province of Jiangxi, People's Republic of China; SMNH 4426, Mt. Feng Yang, Province of Zhejiang, People's Republic of

China; MNHN 1969.4, Taiwan; MNHN 1990.4246, Thailand; MNHN 1991.295, Thailand (from pet trade); NRC 1345, Tung Salaeng Luang, Province of Phitsanulok, Thailand; NRC 1347, Pak Chong Chai Sakaerat, Province of Nakhon Ratchasima, Thailand; NRC 1422, Pak Chong Chai Sakaerat, Province of Nakhon Ratchasima, Thailand; NRC 1424, Pak Chong Chai Sakaerat, Province of Nakhon Ratchasima, Thailand; MNHN 1935.110-111, Sapa [Cha Pa] 20 km SW of Lào Cai, Province of Hoang Lien So'n, Vietnam.

Tropidolaemus wagleri: MNHN 4062, Java, Indonesia; MNHN 4063, Sumatra, Indonesia; MNHN 7767, Sumatra, Indonesia; MNHN 1879.708, Bedagneh River, Deli, now Bedagai River, Province of Sumatera Utara, Sumatra, Indonesia; MNHN 1880.43, Sumatra, Indonesia; MNHN 1880.432-434, Borneo; MNHN 1991.2721, Java, Indonesia; MNHN 1880.435, Sandakan, State of Sabah, Borneo, Federation of Malaysia; MNHN 1884.160-161, Malaya, Federation of Malaysia; MNHN 1906.14, No Sang, State of Sabah, Borneo, Federation of Malaysia; MNHN 1880.232, Albay Province, Luzon, Philippine Islands; MNHN 1880.383, Sulu Archipelago, Philippine; MNHN 1884.46, Philippine; MNHN 1884.181-182, Philippine; MNHN 1891.82, Sebroeang, Borneo; MNHN 1957.817, Borneo; MNHN 1990.4250, Thailand (from pet trade); MNHN 1878.365-366, both labelled "Mansinam, Nouvelle Guinée", unknown origin; MNHN 1990.4287, Thailand (from pet trade).

Trimeresurus trigonocephalus: MNHN 245, Sri Lanka; MNHN 1890.68, Sri Lanka.

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**A NEW SPECIES OF *POLYPEDATES* (ANURA: RHACOPHORIDAE)
FROM THE WESTERN GHATS, INDIA, ALLIED TO THE
SRI LANKAN *P. CRUCIGER* BLYTH, 1852**

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(with two text-figures)

ABSTRACT.- A new species of *Polypedates* is described from southern Tamil Nadu State, south-western India. The new species, *P. pseudocruciger* is closely related to *P. cruciger* Blyth, 1852, from the mid hills and low country of Sri Lanka, from which it can be differentiated in showing a obtuse cutaneous spur on heel (vs absent); skin of forehead free (vs co-ossified to the fronto-parietal and squamosal bones); toe I webbing between distal and distal, subarticular tubercles; and tympanum diameter over 80 (vs less than 65) per cent diameter of orbit. Because of the attempt in the literature to synonymise *Polypedates* under *Rhacophorus*, the new species has been compared with members of both these genera from south-western India and Sri Lanka.

KEY WORDS: Anura; Rhacophoridae; *Polypedates pseudocruciger*; new species; Western Ghats; India.

INTRODUCTION

The Western Ghats is a range of mountains that run for 1,600 km along the western coast of India, and is one of 18 hot spots of biological diversity on earth (Myers, 1988; 1990). Although the amphibian fauna of the region is generally known to be diverse in terms of both species richness and endemism (see for instance, Inger and Dutta, 1986; Inger et al., 1987; Dutta, 1997), there have been relatively few taxonomic revisions for amphibian groups or intensive local sampling from these hill ranges in the last 100 years. The fauna thus has remained relatively unknown, and includes a number of ranid and rhacophorid species that reportedly co-occur in Sri Lanka. We describe here the rhacophorid reported earlier by Daniels (1991; 1992a; 1992b; 1997) and Daniels and Ravichandran (1995) as *Polypedates cruciger* Blyth, 1852 as a new species, and compare it with congeners from both south-western India and Sri Lanka.

We assign the new species to the genus *Polypedates* Tschudi, 1838 sensu Liem (1970), see also Gorham (1974), for the weakly webbed fingers; presence of vomerine teeth; large digital disks; absence of tarsal and anal folds, dermal

fold along forearm; and dorsum dull coloured, with a dark hour-glass-shaped mark. Being aware of the proposed synonymy of *Polypedates* under *Rhacophorus* by Dubois ("1986" 1987), we have compared it with members of both *Polypedates* and *Rhacophorus* from southern India and Sri Lanka, while retaining it in the genus *Polypedates*, following most recent workers (e.g., Frost, 1985; Duellman, 1993). In Dubois's ("1986" 1987) scheme of classification, the new species is a member of the *Rhacophorus* (*Rhacophorus*) *leucomystax* group of species.

MATERIAL AND METHODS

The type series were preserved in ethanol, and measured ca. seven years after preservation. Descriptions of measurements are given in Das (1995). These include: snout-vent length (SVL), tibia length (TBL), head length (HL), head width (HW), head depth (HD), eye diameter (ED), eye to nostril distance (E-N), eye to snout distance (E-S), horizontal tympanum diameter (HTYD), vertical tympanum diameter (VTYD), interorbital distance (IO), internarial distance (IN), upper eyelid width (UE), and FIIND (width of disk of finger III). Sex and maturity were determined

through examination of the gonads. Institutional acronyms follow Leviton et al. (1985). In addition, ZSI/SRS is the Southern Regional Station of the ZSI. Comparative material examined is listed in Appendix I. These include the syntypes of *Polypedates cruciger* Blyth, 1852, reported as not traced by Dutta and Manamendra-Arachchi (1996). Additional sources for information on species include Boulenger (1882; 1890), Dutta and Manamendra-Arachchi (1996) and Kirtisinghe (1957). We use the nomenclature and distribution data from Frost (1985) and Duellman (1993).

***Polypedates pseudocruciger* sp. nov.**
(Figs. 1-2)

Holotype.- ZSI/SRS VA 1077 (field no. RJRD 16), adult male, Glenbeck Estates, near Nagercoil, Kanyakumari District (08° 15'N; 77° 25'E), Tamil Nadu State, southern India. Collected by R. J. Ranjit Daniels, 11 June, 1990.

Paratypes.- BNHM 2863 (field no. RJRD 27), adult male, Maramalai (08° 11'N; 77° 29'E), Kanyakumari District, Tamil Nadu State, south-western India; 12 June, 1990; collector as above; BNHM 2887 (field no. RJRD 28), adult male, Coondapur (13° 38'N; 74° 42'E), Dakshin Kannada District, Karnataka State, south-western India; 11 November, 1990; collector as above.

Diagnosis.- A medium-sized species of *Polypedates*, differentiable from congeneric species, in addition to nominal species of the genus *Rhacophorus* from south-western India and Sri Lanka in possessing the following suite of characters: male SVL 48.0-55.0 mm; an obtuse cutaneous spur on heel; skin of forehead free; tympanum diameter over 80 per cent diameter of orbit; finger II greater than finger I; fingers with basal webbing; nuptial pad on dorsal surface of finger I; absence of a dermal fold along forearm; lack of a median lingual papilla; and dorsum with a dark hour-glass-shaped marking.

Description of holotype.- SVL 48.0 mm. Habitus slender; head short (HL/SVL ratio 0.33) and broad (HW/SVL ratio 0.31), its length slightly exceeding its width (HW/HL ratio 0.94). Snout obtusely pointed when viewed dorsally, slightly rounded, projecting beyond level of mandible; nostrils oval, slightly protuberant,

dorso-laterally oriented, closer to tip of snout than to orbit (E-N/E-S ratio 0.75); internarial region slightly convex. Canthus rostralis vertical in transverse section; lores concave. Orbit large (ED/HL ratio 0.37); eye diameter slightly less than eye-nostril distance (ED/E-N ratio 0.98); interorbital distance greater than upper eyelid width (IO/UE ratio 1.07); interorbital region flat, lacking a dermal fold. A distinct supratympanic fold from posterior edge of upper eyelid, to beyond insertion of forelimb. Tympanum distinct, oval, flat, situated close to the border of orbit and dorso-ventrally in relationship to orbit; and in contact with angle of jaws. Horizontal diameter of tympanum greater than vertical diameter (HTYD/VTYD ratio 1.17); horizontal diameter greater than three-quarter orbit diameter (HTYD/ED ratio 0.83). Vomerine teeth in two oblique, contiguous series in anterior half of choanae, separated by a distance greater than length of each group. Inferior aspect of upper jaw with a weak nick; anterior margin of mandible with a symphysis, giving it a W-shaped notch. Tongue large (tongue length 13.1 mm), elongate (tongue width 9.1 mm), smooth, lacking a median papilla, bifid and free posteriorly for approximately 37.4 per cent of length.

Forelimbs long; tips of fingers dilated into large, flattened, rounded disks with circummarginal grooves. Largest disk (on finger III) less than half horizontal tympanum diameter (FI/II/HTYD ratio 0.48). Fingers I and II unwebbed; fingers III and IV with weak webbing that reach first subarticular tubercle; outer edges of fingers I and IV with a narrow dermal fringe. Subarticular tubercles on palms large, rounded, larger than those on foot. Relative length of fingers: 3>4>2>1. Hind limbs long (TBL/SVL ratio 0.54). Tips of toes dilated into flattened disks with circummarginal groove and smaller than on fingers. Broad webbing on toe: on outer edge of toe I, between distal subarticular tubercle and disk; on inner edge of toe II, up to distal subarticular tubercle; on outer edge of toe II, up to base of disk; on inner edge of toe III, to the base of disk; on outer edge of toe III, between distal subarticular tubercle and disk; on both inner and outer edge of toe IV, to distal subarticular tubercles, reaching the base of disk as a narrow sheath;

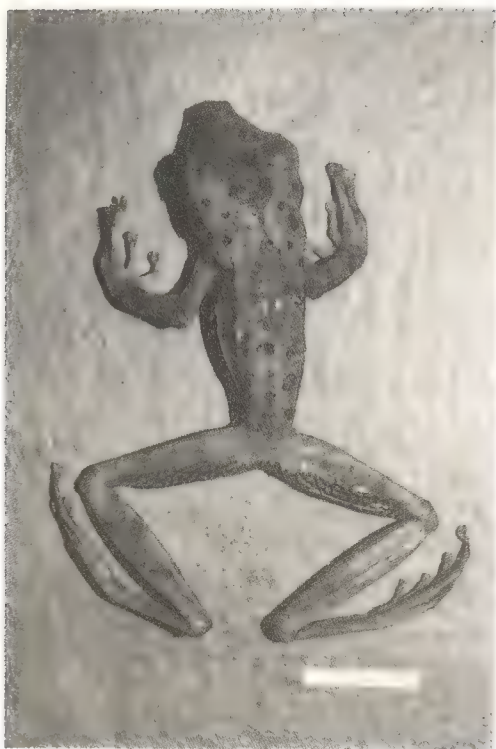


FIGURE 1: Dorsal view of the preserved holotype of *Polypedates pseudocruciger* (ZSI/SRS VA 1077). Marker = 15 mm.

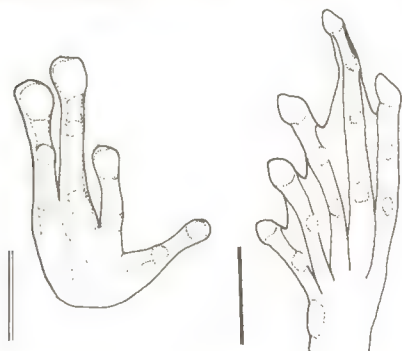


FIGURE 2: Fore (left) and hind limbs (right) of the holotype of *Polypedates pseudocruciger* (ZSI/SRS VA 1077) showing subarticular tubercles and webbing. Markers = 5 mm.

and on inner edge of toe V, between the distal subarticular tubercle and base of disk. A small but distinct and elongated inner metatarsal tubercle present. Relative length of toes: $4 > 5 > 3 > 2$

> 1 . Limbs lack dermal appendages. Tarsal ridge absent.

Wolffian duct convoluted and vesicula seminalis absent. Cloacal opening situated on upper half of thighs, directed ventro-posteriorly.

Skin over cranium free, not co-ossified to either frontoparietal, nasal or squamosal bones. Dorsum with fine, scattered tubercles. Outer edge of upper eyelids with coarse granules. Supratympanic fold fleshy. Throat smooth. Abdominal regions with fine tubercles. Undersurface of forelimbs and top of undersurface of thighs smooth; posterior edge of hind limbs smooth, except for thighs, which show large, scattered tubercles. A light coloured, velvety nuptial pad present on dorsal surface of finger I. A single median vocal sac, but no gular gland present.

Colour (in preservative).- A tan hour-glass-shaped marking is present on dorsum, which is yellowish-grey, with scattered dark brown spots on snout, postorbital and sacral regions, and lateral aspect of torso. A dark brown stripe along supratympanic fold. Tympanum yellowish-brown, darker than surrounding areas. Ventrums unpatterned pale yellow. Lower surface of mandible with a narrow dark edge. Dorsal surfaces of fore and hind limbs with dark grey cross-bars. Posterior surface of thighs with dark brown and yellow reticulations. Ventral surface of foot brownish-grey, contrasting sharply with yellowish-brown of dorsum.

Etymology.- The specific name reflects the close relationship between the new species and its congener from Sri Lanka, *Polypedates cruciger* Blyth, 1853. We suspect many other species that are at present considered to co-occur in the mid hills and low country of Sri Lanka and the Western Ghats, will in the future prove to be non conspecific.

Natural history notes.- Distributional and natural history notes on the type series have been published by Daniels (1991; 1992a, 1992b; 1997) and Daniels and Ravichandran (1995). The type series is part of a group of calling males that were found on a rainy night in mid-June, at 1915 hours, within a clove plantation in Kanyakumari District, Tamil Nadu State, southern India, at an elevation of 400 m above msl. They were

Table 1: Measurements (in mm) of the type series of *Polypedates pseudocruciger*. See text for details.

| | ZSISRS | BNHM | BNHM |
|------------------------------|--------|------|------|
| | 1077 | 2863 | 2887 |
| Sex | male | male | male |
| Snout-vent length | 48.0 | 50.8 | 55.0 |
| Axilla-groin distance | 20.7 | 23.4 | 27.1 |
| Head length | 15.8 | 16.5 | 15.7 |
| Head width | 14.8 | 14.9 | 16.9 |
| Head depth | 8.0 | 9.1 | 10.0 |
| Eye diameter | 5.8 | 6.8 | 6.6 |
| Upper eyelid width | 4.3 | 4.3 | 4.6 |
| Interorbital distance | 4.6 | 4.7 | 6.6 |
| Internarial distance | 3.7 | 3.8 | 4.6 |
| Horizontal tympanum diameter | 4.8 | 3.9 | 4.6 |
| Vertical tympanum diameter | 4.1 | 3.8 | 4.2 |
| Eye-snout-tip distance | 7.9 | 8.2 | 8.8 |
| Eye-nostril distance | 5.9 | 5.8 | 5.5 |
| Eye-tympanum distance | 0.6 | 1.2 | 1.0 |
| Tibia length | 25.8 | 25.1 | 31.4 |

perched about 1 m from the ground on shrubs. The call has been described as "a harsh tre...chuck repeated by rival males followed by a series of chucks of low intensity" (Daniels and Ravichandran, 1995). The species has also been observed at Charmadi Ghat and Baidur, Karnataka State, south-western India, at an altitude of 50-250 m above msl (Daniels, 1992b; 1997; Daniels and Ravichandran, 1995), and more recently, at Kalpetta, Wyanad, Kerala, south-western India, where several males were heard calling both during the day and at night, on 13 June, 1997 (Daniels, pers. comm., 1997). At Charmadi Ghat, the frog was observed crossing a road on a rainy night, while the paratype from Coondapur was observed asleep on a tree trunk during the day (Daniels, pers. comm., 1997). The species has

also been sighted at Top Slip, Anaimalai Hills, Tamil Nadu State, south-western India, at an altitude of over 1,000 m above msl (Daniels, pers. comm., 1997). Earlier, Daniels (1992a) gave the altitudinal range of the species as 0-600 m above msl.

COMPARISONS

There is little new published information on the taxonomy and systematics of the rhacophorids of the Western Ghats, making identifications difficult. The field guide to the group by Daniel and Sekar (1989) deals with a part of this species rich fauna, and many described taxa are in need of re-evaluation and redescription. Dubois ("1986" 1987) considered *Polypedates* to be synonymous with *Rhacophorus*, and suggested further work on the group. We have taken a conservative stance in allocating of the present material to the genus *Polypedates*, based on Liem's (1970) work.

The new species differs from *Polypedates cruciger* Blyth, 1852, in having an obtuse cutaneous spur on heel (absent in *cruciger*); skin of forehead free (vs co-ossified to fronto-parietal and squamosal bones); toe I webbing between distal and penultimate (vs to distal) subarticular tubercles; and tympanum diameter over 80 (vs less than 65) per cent diameter of orbit.

In the following sections, the new species is compared with known members of the genus *Polypedates* from southern India and Sri Lanka; only characters that separate these taxa from the new species have been listed. Both *P. maculatus* (Gray, 1834); distribution: peninsular and northern India and Bangladesh (the endemic subspecies *biscutiger* [Peters, 1871] is distributed in Sri Lanka) and *P. leucomystax* Gravenhorst, 1829; distribution: north-eastern parts of India, extending east into south-east Asia; in skin of forehead

Table 2: Measurements (in mm) of fingers and toes of left hand and foot of *Polypedates pseudocruciger*. See text for details.

| | Fingers | | | | Toes | | | | |
|--------------|---------|-----|------|-----|------|-----|------|------|------|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 5 |
| ZSI/SRS 1077 | 5.2 | 6.5 | 11.4 | 9.8 | 5.5 | 8.7 | 13.4 | 18.5 | 14.9 |
| BNHM 2863 | 5.5 | 7.3 | 10.9 | 7.9 | 4.8 | 7.4 | 12.2 | 16.9 | 13.3 |
| BNHM 2887 | 7.7 | 7.9 | 13.4 | 9.3 | 5.8 | 9.9 | 15.3 | 22.0 | 17.2 |

co-ossified to the cranial bones; reduced toe webbing; and dorsum unpatterned or spotted (in *P. maculatus*) or with a linear pattern (*P. leucomystax*). In addition, in *P. maculatus*, fingers I and II are subequal. The two Sri Lankan endemics, *P. eques* Günther, 1858, and *P. longinasus* Ahl, 1931, show relatively smaller tympanum—48.1–60.0 per cent in the former; 43.2–51.4 per cent in the latter. Additionally, *P. longinasus* has an acute snout, and *P. eques* shows subequal fingers I and II and adult male SVL in the range 32.0–42.0 mm, with nuptial pads on dorsal surfaces of fingers I and II.

Because of the proposed synonymy of *Polypedates* with *Rhacophorus* by Dubois ("1986" 1987), we also provide comparisons of the new species with members of the latter genus from south-west India. *R. pleurostictus* (Günther, 1864) and *R. malabaricus* Jerdon, 1870 (toe webbing reaches first subarticular tubercles on all fingers in *pleurostictus* and to base of disks in *malabaricus*; tympanum relatively smaller, being half in *pleurostictus*; two-thirds in *malabaricus*, of orbit diameter; and dorsum green with large dark-edged blotches in *pleurostictus*; green, usually speckled with black and white in *malabaricus*), the poorly known *R. calcadensis* Ahl, 1927 (dermal fold along forearm; extensive webbing on fingers; and interorbital distance greater than upper eyelid width); *R. lateralis* Boulenger, 1883 (extensive webbing on outer three fingers; and dorsum purple with dark spots).

Comparisons are also made with members of the genus *Rhacophorus* from Sri Lanka: *R. cavirostris* Günther, 1868 (SVL of adult males 25.0–30.8 mm; loreal region deeply concave; webbing on toe IV to distal subarticular tubercle on both inner and outer edges; outer edge of forearm with a dermal fringe; and dorsum reddish brown); *R. fergusonianus* Ahl, 1927 (tympanum less than half diameter of orbit; dorsum lacking hour-glass-shaped pattern and adult male SVL 30.0–37.3 mm); *R. macropus* Günther, 1868 (a conical lingual papilla present; tympanum about a quarter or less diameter of orbit; nuptial pad on finger I only; dorsum lacking hour-glass-shaped pattern; and adult male SVL 24.5–29.5 mm); *R. microtympanum* (Günther, 1858) (tym-

panum less than half orbit diameter; conical lingual papilla present; outer metatarsal tubercle present; dorsum lacking an hour-glass-shaped pattern; and adult male SVL range 30.0–36.5 mm); and *R. reticulatus* Günther, 1864 (conical lingual papilla present; tympanum a third of orbit diameter; webbing on toe IV to distal subarticular tubercle on inner edge and between disk and distal subarticular tubercle on outer edge; and dorsum lacking an hour-glass-shaped pattern).

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APPENDIX I

Comparative material examined:

Polypedates cruciger: CM 67582, CM 67687, Sri Lanka; MCZ 20870-72, Queenwood Estate, Dimbulla, Sri Lanka; ZSI 10016, Colombo, Sri Lanka; ZSI 10790, "Ceylon" (= Sri Lanka); ZSI 10176-79, (syntypes of *Polypedates cruciger* Blyth, 1854), "Ceylon" (= Sri Lanka).

Polypedates eques: MCZ 10156-57, "Ceylon" (= Sri Lanka); MCZ 1982, no data.

Polypedates maculatus maculatus: MCZ 451: 1-2, Ambala, Punjab, northern India; ZSI/SRS VA 257, Sitteri, Mamarati Odai, Kalakad Tiger Reserve, Tamil Nadu State, south-western India; ZSI/SRS VA 280, Vayalagam, Pudukkottai, Tamil Nadu State, south-eastern India.

Polypedates maculatus biscutiger: MCZ 10158, "Ceylon" (= Sri Lanka).

Rhacophorus fergusonianus: WHT 00094, Laggala, Knuckles, Sri Lanka.

Rhacophorus lateralis: ZSI/SRS VA 245, Periyar Tiger Reserve, Kerala State, south-western India.

Rhacophorus macropus: MCZ 20873-74, Queenwood Estate, Sri Lanka; WHT 00090, Laggala, Knuckles, Sri Lanka.

Rhacophorus malabaricus: ZSI/SRS VA 786, Sengeltheri, Kalakad Tiger Reserve, Tamil Nadu State, south-western India; ZSI 17710, Near Sargamalnad forest, Mysore, Karnataka State, south-western India.

Rhacophorus microtympanum: MCZ 70878 (holotype of *Rhacophorus dimbullae* Shreve, 1940; synonymy by Gorham, 1974), "Queenwood Estate, Dimbulla, 5000 feet, Ceylon" (= Sri

Lanka); WHT uncatalogued, Horton Plains, Sri Lanka.

Rhacophorus pleurostictus: MCZ 15409, "Malabar" (= southern Western Ghats, Kerala State, south-western India); ZSI 10157, 12513, Nilgiri Hills (Tamil Nadu State, south-western India); ZSI 9550, Madras Presidency (included much of southern India in the first half of the century); ZSI 10632, "South India".

Rhacophorus reticulatus: ZSI 13776, "Ceylon" (= Sri Lanka).

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FEMALE REPRODUCTIVE CYCLE IN *HARDELLA THURJII* GRAY FROM NORTHERN INDIA

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(with four text-figures)

ABSTRACT.- The reproductive cycle in the female *Hardella thurjii* from the Gomti River at Lucknow, Uttar Pradesh State, northern India, was studied. Females mature at carapace length 320-350 mm. Ovaries were quiescent from winter to early summer (November-April). Follicular development took place in a regime of rising environmental temperatures from summer to early monsoons (July-September). Oviposition began in late September and continued through January, a period which extends from about the end of the monsoons through winter in northern India. Clutch sizes ranged from eight to 13 in dissected females. Annual reproductive potential was strongly correlated to female size and ranged from 30 to 100 eggs per season which was achieved through multiple clutching. Eggs ranged from 40-56 mm x 28-36 mm in dimensions and 19-41 gm weight. Incubation periods extended to 273 days and embryos showed diapause. Carapace length of hatchlings ranged from 41-46 mm and weights 12-17 gm. Patterns of seasonal chronology of the reproductive cycles of female aquatic chelonians in northern India via-a-vis environmental temperatures are described. In one group of north Indian turtles, follicular activity takes place in a regime of increasing environmental temperatures while in temperate regions, most turtles show follicular activity when environmental temperatures are decreasing.

KEY WORDS.- *Hardella thurjii*, Bataguridae, Testudines, female reproductive cycle, India.

INTRODUCTION

Reproductive cycles of freshwater turtles in the Oriental region are rather poorly known, the isolated studies being those of Rao (1982; 1986), Rao and Shaad (1985), Yadava (1983) and Aufenberg and Khan (1991). In general, there is a dearth of published works on reproduction and particularly reproductive cycles of turtles of the region, the information in existence being largely anecdotal or fragmentary (reviewed by Das, 1995). The reproductive cycles of several turtles of the temperate zone have been studied (reviews by Moll, 1979; Georges, 1987) and show a degree of seasonal conformity that confounds attempts to explain seasonally divergent cycles. The paucity of similar studies in different zoogeographic regions preclude plausible explanation of the diversity of cycles and attainment of a wider perspective of this aspect of chelonian reproduction. The present study was an attempt

to fill some of the gaps in our knowledge of chelonian reproduction in general and add to information on the biology of turtles of the Indian region in particular.

This paper describes aspects of the female reproductive cycle in *Hardella thurjii*, a batagurid occurring in Pakistan, northern India and Bangladesh.

MATERIALS AND METHODS

Twenty-seven female *Hardella thurjii* were collected from the Gomti River, near Lucknow City (26° 55'N; 80° 59'E), Uttar Pradesh State, northern India. Except for March, when a single specimen was examined, at least two specimens were examined every month. Turtles were weighed, measured and sacrificed, usually within two to three days of capture, by intramuscular injection of sodium thiopentone or by decapitation in larger specimens. After removal of the plastron,

TABLE 1: Seasonal variation in ovarian structures and oviducal eggs in *Hardella thurjii*. Numbers of corpora lutea in parentheses. Carapace length in mm; weight in kg.

| Sl. | Date dissected | Carapace length | Weight | Ovarian Index | Cl. II | Cl. III | Cl. IV | Cl. V | Fresh | Medium | Old | Oviducal eggs |
|-----|----------------|-----------------|--------|---------------|--------|---------|--------|-------|-------|--------|-----|---------------|
| 1 | 26.3.1989 | 320 | 4.5 | 0.400 | 27 | - | - | - | - | - | - | - |
| 2 | 20.4.1989 | 391 | 6.8 | 3.073 | 20 | 42 | 10 | - | - | - | - | - |
| 3 | 16.4.1989 | 402 | 7.8 | 1.603 | 29 | 21 | - | - | - | - | - | - |
| 4 | 22.5.1989 | 418 | 9.6 | 1.281 | 50 | 24 | - | - | - | - | - | - |
| 5 | 12.5.1990 | 367 | 5.7 | 1.965 | 21 | 25 | 4 | - | - | - | - | - |
| 6 | 30.5.1990 | 365 | 6.35 | 4.094 | 24 | 16 | 10 | 10 | - | - | - | - |
| 7 | 5.6.1989 | 370 | 6.4 | 4.230 | 6 | 24 | 16 | 11 | - | - | - | - |
| 8 | 18.7.1989 | 384 | 8.0 | 5.788 | 12 | 13 | 18 | 27 | 15 | - | - | 15 |
| 9 | 28.7.1990 | 485 | 14.4 | 6.910 | 5 | 20 | 28 | 61 | 15 | - | - | 15 |
| 10 | 10.8.1990 | 412 | 7.7 | 6.831 | 8 | 6 | 11 | 31 | 11 | - | - | 11 |
| 11 | 12.8.1989 | 410 | 9.0 | 7.260 | 9 | 9 | 16 | 38 | 8 | - | - | 8 |
| 12 | 21.8.1989 | 350 | 5.2 | 3.942 | 15 | 16 | 19 | - | 11 | - | - | 8 |
| 13 | 24.9.1990 | 386 | 8.9 | 4.551 | 2 | 30 | 29 | 21 | 14 | - | - | 13 |
| 14 | 30.9.1990 | 379 | 6.5 | 1.490 | 1 | 3 | 10 | - | - | 14 | 5 | - |
| 15 | 16.10.1990 | 364 | 7.25 | 1.876 | 2 | 10 | 15 | - | - | 30 | - | - |
| 16 | 24.10.1990 | 483 | 15.5 | 3.374 | 8 | 13 | 1 | 38 | - | 19 | - | - |
| 17 | 9.11.1988 | 378 | 8.5 | 0.810 | 45 | 6 | - | - | - | 71 | - | - |
| 18 | 26.11.1990 | 467 | 14.0 | 2.130 | 65 | 43 | 7 | 12 | - | 79 | - | - |
| 19 | 19.12.1988 | 372 | 5.6 | 0.875 | 12 | 10 | - | - | - | - | - | - |
| 20 | 23.12.1988 | 395 | 7.35 | 1.129 | 30 | 15 | - | - | - | - | 8 | - |
| 21 | 2.1.1991 | 314 | 3.9 | 0.154 | - | - | - | - | - | - | - | - |
| 22 | 28.1.1989 | 370 | 5.5 | 1.930 | 31 | 31 | - | - | - | - | 2 | - |
| 23 | 30.1.1989 | 429 | 10.2 | 2.920 | 31 | 24 | 14 | 9 | - | 25 | - | - |
| 24 | 16.2.1989 | 430 | 9.1 | 0.967 | 39 | 28 | - | - | - | - | - | - |
| 25 | 18.2.1989 | 261 | 2.2 | 0.091 | - | - | - | - | - | - | - | - |
| 26 | 22.2.1989 | 313 | 4.2 | 0.381 | - | - | - | - | - | - | - | - |
| 27 | 22.2.1991 | 447 | 11.2 | 1.803 | 41 | 54 | - | - | - | 38 | - | - |

ovaries were trimmed of oviduct and mesovarium, and weighed to the nearest gm on a counterbalance. Fresh ovaries were examined for the occurrence of corpora lutea, which, if present, were measured and counted separately for the left and right ovaries. Ovaries were fixed in 10 percent formalin. The hardened follicles exceeding 5 mm in diameter were measured at their widest point with dial vernier callipers. All oviducal eggs were removed, counted separately for the right and left oviducts, measured and weighed to the nearest 0.1 gm. Eggs obtained from oviducts of dissected turtles between 28 July and 24 September, 1990, were kept indoors for incubation in a medium of moist earth in a plastic tub. Eggs deposited underwater by a captive female in 1991

were incubated in earth at a depth of ca. 15 cm. The maximum and minimum temperatures of the incubation medium of the tub were monitored.

Ovarian Index was calculated for each turtle as the combined weight of the trimmed ovaries expressed as a percentage of female body weight. Follicles were classified by their diameters as belonging to five size classes: I- 'germinal oocytes', these were numerous, whitish in colour, 5 mm in diameter; they were not counted; II- size range 5-12 mm; III- size range 13-19 mm, 'vitellogenic follicles', they were yellowish in colour indicating that they have begun to acquire yolk. Found in the ovaries of mature females throughout the year; IV- 20-24 mm, 'pre-ovulatory follicles', these appear after the end of the quiescent

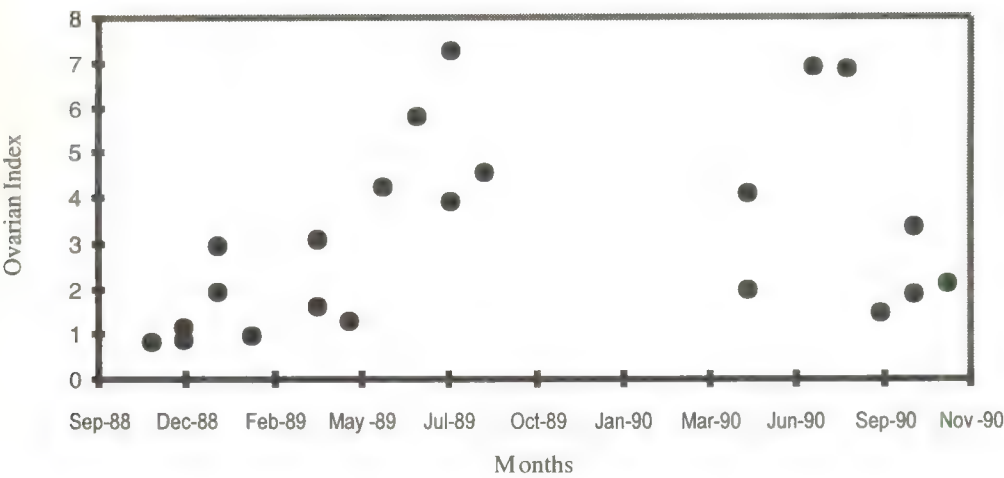


FIGURE 1: Seasonal variation in Ovarian Index (weight of ovaries as percentage of body weight) for 23 mature female *Hardella thurjii*.

period by follicular growth due to rapid vitellogenesis. While greater in size than vitellogenic follicles, they are smaller than follicles that ovulate; V- size range 25 mm, ‘ovulatory follicles’; these large size class of follicles occur only during the ovulation season.

RESULTS AND DISCUSSION

Details of turtles dissected, dates, carapace lengths, body and ovarian weights, size class composition of follicles, ovarian indices, number and category of corpora lutea and the number of oviducal eggs are provided in Table 1.

TABLE 2: Distribution of oviducal eggs in paired oviducts of gravid *Hardella thurjii*. Specimens marked with asterisks showed evidence of trans-coelomic migration.

| Sl. | No. of corpora lutea | | No. of oviducal eggs | | |
|-----|----------------------|-------|----------------------|---------------|----------------|
| | Left | Right | Left oviduct | Right oviduct | Cloacal region |
| 1 | 8 | 7 | 8 | 7 | - |
| 2 | 6 | 2 | 2 | 2 | 2 |
| 3 | 8 | 3 | 2 | 2 | 4 |
| 4* | 7 | 8 | 4 | 11 | - |
| 5* | 8 | 6 | 4 | 9 | - |

Female size at maturity.- Of the females examined, four (nos. 1, 21, 25 and 26) were considered immature because of the following characteristics: 1. Ovarian Index- even in the quiescent period, the ovarian follicles of mature females were 0.8 (lowest in the quiescent period 0.810; no. 17). The ovarian indices of immature females ranged from 0.091-0.400; 2. Maximum size of follicles present- Ovaries of mature fe-

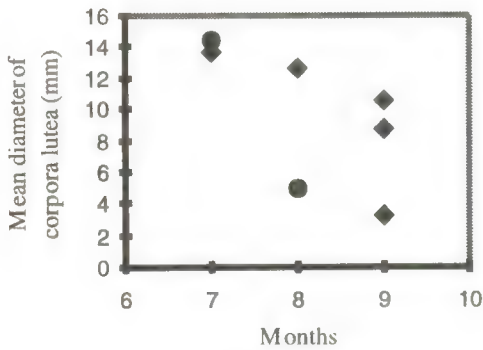


FIGURE 2: Plot of mean diameter of corpora lutea (mm) associated with the first clutch ovulated by *Hardella thurjii*. Circular plots are for females dissected in 1989; rhombic plots for 1990.

males bore follicles up to 20 mm in diameter even during the quiescent period, but immature females had few follicles that exceeded 5 mm, and none of these 10 mm, or no follicles at all; 3. Development of the oviduct- In immature females, oviduct diameter did not exceed 5.6 mm, whereas the oviduct diameter of one of the smaller sexually mature females (no. 19) was 10.5 mm.

By the above criteria, females of *Hardella thurjii* reach sexual maturity at carapace lengths 320-350 mm, and weight 4,500-5,000 gm. The largest sexually immature female encountered (no. 1) was 320 mm (carapace length) and 4.5 kg (weight).

Ovarian quiescence.- Following ovulation and oviposition, the ovaries enter their quiescent stage. During this period, follicles from classes IV and V are absent from the ovaries. In eight females in which quiescence was observed, the diameter of class III follicles did not exceed 18.5 mm. While the quiescent period of the ovaries appear to extend from November to April/May, considerable variability in the timing of initiation of quiescence was apparent. Thus, whereas an

8.5 kg female (no. 17) lacked even class IV follicles, as early as 9 November, a female (no. 23) weighing 10.2 kg retained a set of nine ovulatory class follicles on 30 January. Thereafter, ovulatory class follicles were not observed before end May. A notable feature of quiescence of ovaries in *Hardella* was the renewal of follicles of classes II and III in this phase by vitellogenesis of germinal oocytes. Thus, ovaries of 13 females of mean weight 8.33 kg in quiescent phase with ovarian index (2.92, bore a mean of 53.2 class II and III follicles, significantly more than the mean of 29.8 follicles of these classes (t-test; $t = 2.29$; $df = 21$; $P < 0.05$) on ovaries of 10 similar sized females of mean weight 8.83 kg ($t = 0$; $df = 21$; $P < 0.05$ in recrudescence phase with Ovarian Index 2.92. This indicates that even during the quiescent period, some follicular activity goes on by way of vitellogenesis of germinal oocytes. In parallel situations for *Trachemys scripta* in Panama (Moll and Legler, 1971) and *Emydura krefftii* in Australia (Georges, 1983), no significant reduction in the number of follicles with diameters between 7-13 mm is noticeable for the former species, although the latter does show a

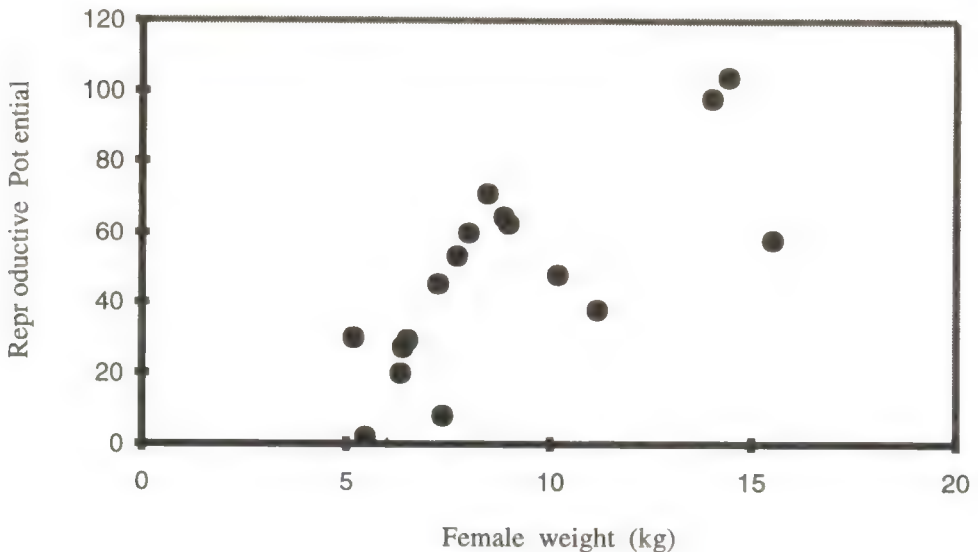


FIGURE 3: Relationship of Reproductive Potential (total of pre-ovulatory, ovulatory sized follicles, oviducal eggs and corpora lutea not associated with oviducal eggs) to female weight in *Hardella thurjii*. the regression line is: Reproductive Potential = -10.9 + 6.56 Female Weight ($r = 0.73$, $P < 0.05$; $n = 17$, $df = 15$).

TABLE 3: Dimensions (mm) and weights of egg (gm) obtained from the oviducts of gravid *Hardella thurjii* (weights in kg). Range of measurements along with means in parentheses.

| Sl. | Clutch size | Female weight | Carapace length | Egg | | |
|-----|-------------|---------------|-----------------|-----------------------|-----------------------|-----------------------|
| | | | | length | width | weight |
| 1 | 8 | 5.2 | 350 | 43.2 - 46.7 (44.8) | 27.8 - 28.9 (28.2) | 20.5 - 22.5 (21.3) |
| 2 | 11 | 7.7 | 412 | 51.5 - 58.5 (54.6) | 31.0 - 35.8 (33.3) | 32.5 - 42.7 (36.3) |
| 3 | 15 | 8.0 | 384 | 52.6 - 60.3 (55.8) | 31.8 - 34.7 (32.7) | 33.5 - 37.5 (35.3) |
| 4 | 13 | 8.9 | 400 | 43.5 - 53.6 (48.6) | 27.1 - 30.7 (28.7) | 19.6 - 29.0 (24.3) |
| 5 | 8 | 9.0 | 410 | 30.2 - 54.1 (51.3) | 34.2 - 36.1 (35.3) | 36.5 - 41.0 (39.1) |
| 6 | 15 | 14.4 | 485 | 51.8 - 56.1 (53.8) | 34.9 - 38.0 (35.9) | 38.0 - 46.2 (40.6) |

reduction in the number of follicles of diameters between 4-10 mm during this period, when the largest size class of follicles are present.

Follicular enlargement.- Follicular enlargement was first noticed in late April, with the appearance of class IV follicles. All specimens examined beyond the end of May to the latter part of October contained classes IV and V follicles, and often oviducal eggs. Follicular activity was the greatest between June and mid-August, when ovarian indices increases rapidly (Fig. 1). Although ovulatory class follicles continued to occur till mid-October, or even later in two instances, ovarian indices declined steadily from mid-August onwards. This indicates a temporary halt to follicular activity that prevents ovulating follicles from being replaced. This, along with the observed reduction in the number of smaller size class of follicles as the ovulation season progresses, supports the contention that in *Hardella* follicular activities of the two types: i. the growth of vitellogenic follicles to ovulatory size; and ii. the initiation of vitellogenesis in germinal oocytes takes place in two discrete phases.

Ovulation and corpora luteum.- Ovulation was first noted in mid-July, following the onset of the monsoons. Between this time and late September, a period roughly coinciding with the passage of the Southwest Monsoons in northern India, all six samples examined had oviducal eggs, equal or slightly less in number to the number of corpora lutea, and therefore represents

the period in which the first clutch is ovulated. In two specimens (nos. 12 and 13), corpora lutea numbered 11 and 14, while the number of oviducal eggs were eight and 13, respectively. While in the latter specimen, this could represent the loss of ova during coelomic migration, in the former, the possibility of unobserved oviposition under stress of capture cannot be ruled out, because on dissection, four of the eight eggs were discovered to have descended from the oviduct into the cloacal region.

The greatest diameter of corpora lutea ranged from 13.3-17.8 (mean 14.6) mm in a turtle (no. 8) that was dissected on 18 July. Another turtle (no. 20) dissected 25 days later (on 12 August), which had also ovulated its first clutch, showed luteal regression and diameters of its corpora lutea ranged from 4.5-5.4 mm, with a mean of 5.0 mm. In three turtles (nos. 9, 10 and 13) dissected 13 and then 45 days apart on 28 July, 10 August

TABLE 4: Measurements (in mm) and weights (in gm) of hatchling *Hardella thurjii*. Years mentioned are those in which the eggs were incubated. Hatchlings emerged in 1991 and 1992, respectively.

| | 1990 (n = 8 clutches) | | 1991 (n = 5 clutches) | |
|-----------------|--------------------------|------|--------------------------|------|
| | Range | Mean | Range | Mean |
| Weight | 11.8 - 16.5 | 14.4 | 16.4 - 23.2 | 20.9 |
| Carapace length | 41.4 - 45.5 | 43.6 | 46.2 - 52.5 | 50.1 |
| Carapace width | 32.6 - 34.7 | 34.4 | 37.7 - 42.1 | 43.2 |
| Plastron length | 37.5 - 42.5 | 39.5 | 39.7 - 46.9 | 44.2 |
| Shell height | 20.5 - 23.4 | 22.2 | 22.1 - 25.7 | 24.2 |

TABLE 5: Proposed pattern of female reproductive cycles in relationship to ambient temperature regimes among north Indian freshwater turtles. See text for descriptions of patterns. Mean monthly temperatures in north India shown in Figure 4. Asterisks indicate comments by respective authors.

| Species | Reproductive period | | Source |
|------------------------------------|--|--|----------------------------|
| | Follicular growth | Oviposition | |
| Pattern I | | | |
| <i>Hardella thurjii</i> | April - August | September - January | Present study |
| <i>Aspideretes gangeticus</i> | April - September/October | - | Rao (1986) |
| | - | July - November | Unpublished information |
| <i>Aspideretes hurum</i> | Not studied | October - November | Unpublished information |
| | - | winter months | Das (1991; 1995) |
| <i>Kachuga smithi</i> | April - August/September | - | Auffenberg and Khan (1991) |
| | - | Beyond early October | Minton (1966) |
| | - | August - mid November | Gupta (1987) |
| <i>Lissemys punctata andersoni</i> | Not studied | November | Minton (1966) |
| | - | August - October | Duda and Gupta (1982) |
| | - | August - October | Bhowmik (1970) |
| <i>Chitra indica</i> | Not studied | August - September | Bhadoria et al. (1990) |
| | - | Late June | Unpublished information |
| Pattern II | | | |
| <i>Kachuga tentoria</i> | Beginning of follicular cycle not known. Post-ovulation females in Dec. had no ovulatory follicles (These probably grow through winter for ovulation of 2nd end winter clutch)*. | Late September - February | Rao (1990) |
| <i>K. tectum</i> | Not known. (Species closely related to <i>K. tentoria</i> probably with identical follicular cycle)*. | Known to nest in January | Moll (1987) |
| | Not known | October and February | Das (1991; 1995) |
| Pattern III | | | |
| <i>Kuchuga dhongoka</i> | Not known. Post ovulation female in mid Dec. was without ovulatory follicles. (Through or post winter follicular activity probable for ovulation of end winter/early summer clutch)*. | Sporadic in December. Main nesting occurs from February to April | Rao (1990) |
| <i>K. kachuga</i> | Not known. Post ovulation female in winter had both oviducal eggs and ovulatory follicles. (Species closely allied to <i>K. dhongoka</i> probably with identical reproductive cycle)*. | Sporadic in December. Main nesting occurs from February to April | Rao (1990) |

and 24 September, the diameters of corpora lutea, corresponding to the first clutch ovulated, ranged between 11.0-15.8 (mean 13.6) mm, 10.1-17.8 (mean 12.6) mm and 8.4-12.4 (mean 10.5) mm. Assuming that the rates of regression of corpora lutea remains the same in different animals, comparisons of corpora lutea diameters between two

sets of animals dissected in subsequent years (Fig. 2) suggests that there may be considerable variability in the timing of ovulation of first clutches in different turtles.

Evidence of trans-coelomic migration of ova, whereby the ovum following ovulation finds its way to the contra-lateral oviduct, was found in

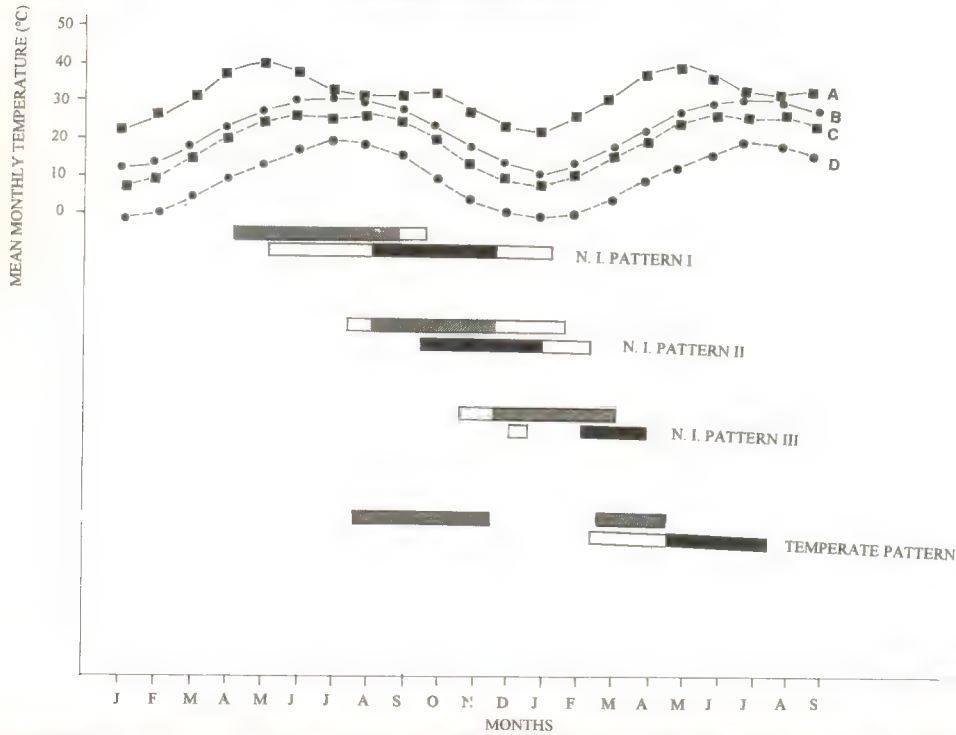


FIGURE 4: Representation of the relationship of proposed patterns of reproductive cycles in freshwater turtles from northern India and in the temperate regions to ambient temperatures. Grey bars represent follicular growth, black bars represent nesting. White portions of bars represent rising or waning periods of reproductive activity towards the beginning or end of the reproductive season. Squares represent ambient temperatures in northern India; circles for those in temperate regions. Continuous lines represent maxima; broken lines, minima. Sources of temperatures include Srivastava (1981) for northern India; Gibbons (1990) for temperate regions. Sources for data on reproductive seasons are in Table 5.

two out of a possible five specimens in which this phenomenon was studied (Table 2). These observations do not conform with those of Georges (1983), in which the net effect was to distribute eggs more evenly between oviducts but seem more due to chance (Moll and Legler, 1971).

Oviducal period of ova, oviposition and nesting season.- The earliest specimen of the year, with ovaries that bore corpora lutea but no oviducal eggs (no. 14) was dissected on 30 September, 1990, indicating oviposition prior to dissection. Assuming that environmental factors would have prevented nesting in *Hardella* from the Gomti River up to at least that time (24 September, 1990), when the last turtle carrying the first clutch was dissected, the nesting season may be inferred to have begun in the last week of September (i.e., between 24-30 September). If this is true, then the period lapsing between the end of July, when the first turtle of the year was carrying

her first clutch oviducally was dissected and the above inferred beginning of the nesting season, i.e., the last week of September, is roughly indicative of the period for which the first clutch may be retained (i.e., approximately seven weeks).

Interestingly, the first turtle (no. 14) to have laid in the year, had completed nesting twice by the end of September, since its ovaries bore a set of 14 larger and newer corpora lutea (diameters 7.0-10.5; mean 8.7 mm) and a second set of five older corpora lutea (diameters 2.0-4.5; mean 3.2 mm). Based on the above estimate of the start of the nesting season, *Hardella* appears to have a short internesting period, as has been reported for several other turtles (Moll, 1979).

In literature, oviposition for the species has been reported variously as at the beginning of the monsoons (Khan, 1987), in August and September (Chaudhuri, 1912), while a female was re-

ported carrying 19 eggs in early January (Vijaya and Manna, 1982). At the Kukrail Crocodile Centre, captives nested from the second week of October till early November. In the present study, three females (nos. 16, 18 and 23) dissected on 24 October, 26 November and 30 January, had class IV and V follicles, representing potential clutches yet to be laid. A single nest of batagurid eggs considered to belong to *Hardella* was located on the Gomti River on 1 November. By integrating all the above reports, the nesting season of *Hardella* may be said to last from the beginning of the Southwest Monsoons (June/July) to the latter part of winter (January/February) in northern India.

The long period of oviducal retention of the first clutch between the end of July and the latter half of September, suggests that for populations from rivers, the cessation of acute fluctuations of river levels and concomittant fluctuations of discharge rates during the monsoons could be an important factor influencing the commencement of the nesting season. On the other hand, populations from stagnant water bodies, such as lakes and ponds, whose levels are not as acutely affected by the monsoons, could conceivably begin nesting earlier. It is also notable that all three examples of *Hardella* which were found bearing ovulatory and pre-ovulatory follicles later in the season (nos. 16, 18 and 23) were fairly large females, whose mean weight was 13.23 kg. This suggests that larger females with presumably greater reproductive potential (see below) may continue to nest later than smaller females. Moll and Legler (1971) stated that this is also the case with *Trachemys scripta* in Panama, with larger females beginning to nest earlier in the season, and continuing later than smaller females.

Multiple clutching and reproductive potential.— Multiple clutching has been widely documented in turtles with simultaneous presence of oviducal eggs and ovulatory sized follicles, corpora lutea and several sets of developed follicles or several sets of corpora lutea, all being regarded as evidence for the production of more than one clutch in a season. In *Hardella*, evidence of multiple clutching was observed in most specimens collected from mid-July to the latter half of October, which, in addition to oviducal eggs or

corpora lutea, possessed ovulatory and pre-ovulatory follicles in approximate multiples of observed clutch sizes. Since these size classes of follicles were not observed outside the reproductive season, it is assumed that these follicles would also be ovulated and incorporated into the year's egg production, although Georges (1983) has provided some evidence that even developing follicles may undergo atresia.

Evidence of multiple clutches in the form of sets of different sized corpora lutea was observed in a single specimen of *Hardella*, which has already been referred to as carrying corpora lutea, but no oviducal eggs. In several other females, large number of corpora lutea in various stages of regression were present, that would probably have resulted from the ovulation of several clutches. Some of these corpora lutea were highly regressed and observable on the ovaries only as scars on the stroma, but since no traces of corpora lutea were found outside the reproductive season, the chance of regressed corpora lutea being left over from the previous season is precluded. The diameters of these corpora lutea ranged from 1.6-10.4 mm, but there were no discrete groupings to facilitate recognition of corpora lutea corresponding to different clutches.

The reproductive potential of *Hardella* from the study area has been estimated by totalling the number of pre-ovulatory and ovulatory sized follicles, oviducal eggs and those corpora lutea not accompanied by oviducal eggs observed in different specimens. This indicates that the estimated reproductive potential is correlated to female body weight (Fig. 3) and increases from about 30 eggs per season in a female of about five kg that have recently acquired maturity, to about 100 eggs per season for an old female weighing in excess of 14 kg. It seemed futile to attempt to estimate the number of clutches over which the reproductive potential is realised since too few clutches have been observed during the present study.

Description of eggs.— Existing information on the eggs of *Hardella thurjii* originate from a single clutch of 19 eggs examined by Vijaya and Manna (1982). The mean length and diameter of these eggs were 51 and 34 mm and their (presumed mean) weight was 20 gm (quoted in Das,

1991). Table 3 makes it clear that the smallest female, which was also the lightest, contained the smallest and lightest eggs, while the largest and heaviest female contained the largest and heaviest eggs. The trend in mean weight was consistently correlated to female body weights. Egg shells were calcareous and brittle, even while in the oviducts.

Incubation period and hatchlings.—Incubation temperatures dropped from a maximum of 34.5° C, recorded in August, 1990 to a minimum of 11.0° C in January, 1991, and then again rose to a maximum of 36.5° C in May, 1991. Eggs from the 1990 batch hatched on 31 May, 1991, after approximately 273 days of incubation, while eggs from the 1991 batch were discovered to have already pipped on 6 June, 1992, after approximately 223 days of incubation. The discrepancy between the incubation periods of the two successive years obviously resulted from the remainder of the oviducal period of the 1990 batch of eggs being added on to the incubation period. The close agreement in the time of hatching of the eggs of the different years along with the fact that rapid embryonic development could be detected during periodic candling of the eggs, only after February of the year following that in which the eggs were produced, makes it almost certain that *Hardella* eggs undergo diapause after oviposition. This is terminated by winter chilling of the eggs (see Ewert, 1979; 1985, for a detailed description of diapause).

Eight hatchlings obtained by incubation of the 1990 batch of eggs were weighed and measured within a week of hatching. The data on sizes and weights are in Table 4.

PATTERNS OF REPRODUCTIVE CYCLE

Hardella thurjii is the largest batagurid turtle in the northern part of the Indian subcontinent, reaching a maximum carapace length of 61 cm (Das, 1991). It inhabits slow flowing streams and rivers, and also lakes and ponds in the flood plains. The reproductive cycle of females do not resemble those shown by turtles inhabiting temperate regions. In these species, the patterns of follicular development (reviewed by Moll, 1979; Georges, 1983) is characterised by growth of follicles in a regime of decreasing ambient tem-

perature between autumn and winter, followed by a cessation of follicular activities during winter brumation. If, as in some species, follicular development is not completed by the advent of winter, this is resumed in spring and continues till summer when ovulation and oviposition take place. Three species have shown notable divergence from this pattern: *Chrysemys picta* and *Dierochelys reticularia* from the temperate regions and *Kinosternon leucostomum* from the tropics (Powell, 1967; Gibbons and Greene, 1978; Moll and Legler, 1971). In *C. picta* from Nova Scotia, the quiescent period of the ovaries is not noticeable while in *K. leucostomum*, follicular activities and ovulation was noticed year round. In *D. reticularia*, spring nesting is followed by autumn nesting with intervening periods of reproductive inactivity in summer and midwinter. The divergent adaptations of *C. picta* and *K. leucostomum* can be explained in terms of influence of environmental conditions. In Nova Scotia, which is the northern distributional limit for freshwater turtles, presumably the low rates of metabolic turnover of *C. picta* resulting from low ambient temperatures, necessitates energy investment throughout the year in the follicles to meet annual reproductive expenditure. It is likely that follicular development is completed over durations in excess of a year, whereby ovarian quiescence was never observed irrespective of the month in which the ovaries have been examined. In the case of *K. leucostomum*, high ambient temperatures of the equatorial environment may be considered to have removed physio-seasonal constraints to energy investment in the follicles, whereby follicular development and ovulation is observed throughout the year. However, the divergent temporal characteristics of the female reproductive cycles of *D. reticularia* cannot be similarly explained and are considered to be enigmatic by Gibbons et al. (1982). Certain turtles in northern Florida, U.S.A., nest continuously throughout the year and in these, follicular activity is less likely to be correlated with declining environmental temperatures, but even in some of these, such as *Sternotherus odoratus* and *Kinosternon baurii*, there is an observed decrease in ovulation and nesting in summer followed by ovarian recrudescence (Iverson, 1977). Accord-

ing to Iverson's (1977) description of the reproductive cycle of continual nesters in Florida, at least a part of follicular activity occurs in the post summer regime of decreasing environmental temperatures.

In contrast to the uniform patterns of the female reproductive cycles of temperate turtles, those of the freshwater turtles in northern India can be classified into two, possibly three, patterns described below. The pattern proposed are based on reproductive cycles that have been determined by direct study in certain species, or inferred from coincident or closely resembling nesting periods in a group of species, to follow a pattern (Table 5).

Pattern I (*Hardella thurjii*, *Aspideretes gangeticus*, *A. hurum*, *Kachuga smithii*, *Lissemys punctata* and *Chitra indica*).

Follicular development is initiated and proceeds in a regime of rapidly increasing ambient temperature. Ovulation of the first clutch takes place by the beginning of the monsoons while ovulation of subsequent clutches and oviposition extends till mid-winter (December to January).

Pattern II (*Kachuga tentoria* and *K. tecta*).

Females of *Kachuga tentoria* contain both ovulatory sized follicles as well as oviducal eggs in November. Nesting occurred in late September to the second half of February. Females examined in mid to late December contained oviducal eggs and corresponding fresh corpora lutea but no ovulatory sized follicles (Rao, 1990). The above suggests that in the species adhering to this pattern, the first pre-winter period of follicular growth is followed by a second period of follicular growth from mid to late winter.

Pattern III (*Kachuga kachuga* and *K. dhongoka*).

Nesting in both the above species was found to occur sporadically in December followed by the main nesting period which extend from February to April. A single specimen each in of *Kachuga kachuga* and *K. dhongoka* examined in December did and did not contain ovulatory sized follicles, in addition to a clutch of oviducal eggs (Rao, 1990). This suggests that in species which show the third pattern, the period of follicular growth has shifted further along a regime of decreasing ambient temperatures with a part

of follicular development taking place in the post-winter period, as in many temperate species. The oviposition of another north Indian species, *Geoclemys hamiltonii* in May (Das, 1995, Basu and Singh, in prep), suggests a reproductive cycle not conforming to any of the above patterns, but in this species too, follicular development conceivably takes place in a post-winter regime of rising environmental temperatures.

Moll (1979) in his discussion of seasonal chronology of reproductive cycles, has suggested that egg and hatchling survival are among the ultimate causes that determine the timing of these cycles, while temperature, light and moisture are important proximate causes, of which temperature is the most important one. The influence of proximate causes are well illustrated by the case of *Trachemys scripta*, which conforms to the general pattern of reproductive cycles in the temperate region where temperature is the major constraint in the determination of the reproductive cycles. However, the cycles of Panamanian populations of *T. scripta*, while still exhibiting the affinities with those of temperate conspecifics, have become altered in response to the sharply differentiated dry and wet seasons of Panama. However, such adaptations amicable to environmental conditions of regions newly colonised by species radiating from their zoogeographical centres of origin, seem different in nature from those of sympatric or syntopic species. Examples of the latter type of adaptation are seen in species like *Deirochelys reticularia* in North America or in groups of species following seasonally different patterns of reproductive activity in northern India.

Future studies of the reproductive cycles of more species, belonging to different isothermal regions in various faunal realms, will reveal if seasonal patterns of reproductive activity, similar to those proposed for the freshwater turtles of northern India, can in fact be identified on a global basis, leading to a valid explanation for this phenomenon.

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NESTING ECOLOGY OF MUGGER (*CROCODYLUS PALUSTRIS*) IN AMARAVATHI, SOUTHERN INDIA

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(with one text-figure)

ABSTRACT.- The reservoir at Amaravathi, Tamil Nadu State, southern India, has been reported to sustain the country's largest mugger (*Crocodylus palustris*) population. A survey of crocodile nests was carried out in the reservoir and stream habitats. Nesting sites in the reservoir during 1976 were different from those utilised during 1994. There was no synchrony in nesting between reservoir and stream habitats. Aggregation of nests in the stream habitat or scattered nesting in the reservoir may have resulted due to differences in the quality of the habitats.

KEYWORDS.- *Crocodylus palustris*, population, nesting patterns, Amaravathi, south India.

INTRODUCTION

The Amaravathi Reservoir has been reported to sustain the country's largest mugger (*Crocodylus palustris*) population (Whitaker and Daniel, 1978; Whitaker, 1979). Amaravathi River and several hill streams drain into the reservoir. This study was conducted to assess the nesting crocodile population in this area. There is anecdotal evidence showing reduction in crocodile population in the reservoir but there has been no study on the nesting population demonstrating such a decline. The objective of this study was to find if there were differences in (a) number of nests laid by the crocodiles in the reservoir between 1976 and 1994, and (b) nesting pattern in the reservoir and stream habitat. This could be of importance for the management of mugger population in man-modified habitats.

The study area is situated in the Indira Gandhi Wildlife Sanctuary in the Western Ghats of Tamil Nadu, between 10° 20'–10° 25' N; 77° 13'–77° 18' E. The reservoir at Amaravathi was commissioned in the late 1950s for irrigation. Semi-intensive aquaculture is practised in the reservoir area.

The reservoir had a waterspread of 9.31 sq km (Satheesh, 1992) and receive an annual rainfall of 650–700 mm. The watershed is surrounded by hills which range from 300 to 1000 m in altitude. The reservoir, the Amaravathi River and the hill

streams are surrounded by mixed deciduous forests (Champion and Seth, 1968). The river course is rocky with patches of sand and the hill streams flow through steep rocky gorge with rapids. The Amaravathi River flows from south to north before emptying into the reservoir after a waterfall at Thuvanam (Fig. 1) and the habitat is similar to that of the Amaravathi. The reservoir bank on the western side has steep rocks in some areas. In most areas the banks were flat and have scanty vegetation. The entire fringe of the reservoir area is forested. During the study the reservoir habitat comprised of the area encompassed by stored water in the reservoir and its forested fringe. The stream habitat comprised of Amaravathi River and Thuvanam including the banks till the edge of the forest.

MATERIALS AND METHODS

The study was conducted between 20 February, 1994 to 18 May, 1994 at Amaravathi. The reservoir and the river course were monitored for nesting by daily visits covering segments of study area described. Nests were located with the help of an experienced local tracker. Tracks of crocodiles and presence of dug out soil on top were indications of a possible nest. Nest parameters such as depth of nest and width of chamber were measured. Egg dimensions and clutch size were also recorded. Nesting date was established



FIGURE 1: Map of the Amaravathi Reservoir, Tamil Nadu, south India, showing the crocodile nesting sites. Scale bar = 670 m.

by the presence of moisture in dug out soil and tracks leading to the nest in relation to water level fluctuation. Similar methods were used during 1976 survey in the study area.

Location of nests laid during 1994 nesting season and nest sites utilised during 1976 were marked on a scaled contour map. Water spread

in the reservoir during the years was also indicated in the same map. Nesting habitat parameters such as water level in the reservoir, distance of nest from water level, rocks and vegetation were measured. Water level was recorded from the gauge at the dam weir. The distance from water was the distance between the nest and the water on the day the nest was discovered. The distance of a nest from the nearest deep pool and other nests were quantified using the map. The inter-nest distance was the distance between a nest and its immediate closest nest when all the nests were joined by straight lines. However, the measurements made between the nests were not repeated. A deep pool was defined as a large water body of diameter (10 m and depth not less than 5 m).

Tracks of crocodiles, trial pits, nesting attempts and nests were recorded. Tracks of crocodiles were distinct on wet soil and it did not resemble any other animal track in the area. Trial pits were identified as shallow cavities made by crocodiles without any eggs being laid on the sand banks during the nesting season. A nesting attempt was differentiated from basking when tracks of the crocodile did not have impression of belly scutes on the substrate. Distinct impressions of belly scutes and hind limbs could be seen only when the animal basked.

Nonparametric and parametric tests were employed to find differences in nesting habitat and nest parameters. To find, if there was temporal order in the choice of nesting site Markov analysis (Martin and Bateson, 1986) was carried out. The chronological sequence of nesting events were categorised based on the associated preceding event. A matrix was constructed for frequency of the combination of events. Kolmogorov-Smirnov one sample goodness of fit test (Siegel and Castellan, 1988) was conducted to test for synchrony. Wilcoxon-Mann Whitney small sample test (Siegel and Castellan, 1988) was conducted on habitat parameters, since these data were not normally distributed. The nesting population in the reservoir and in Thuvanam were considered to be two distinct groups and were considered as independent variables.

TABLE 1: Comparison of *Crocodylus palustris* survey results from 1976 and 1994 October, Amaravathi, Tamil Nadu.

| Nest and Habitat parameters | 1976 | 1994 |
|--|--------------------------|-------------------------|
| Total nests located in reservoir | 11 | 5 |
| Nesting season | 29-February to 14-March | 26-February to 19 March |
| Mean clutch size (range) | 30.9 (26 - 35) | 37.0 (33 - 40) |
| Mean egg length and range | 73.86 (63.75 - 83.75) mm | 76.69 (68.13 - 80.6) mm |
| Mean egg width and range | 46.72 (43.75 - 47.5) mm | 49.92 (44.6 - 52.9) mm |
| Mean inter-nest distance and range | not available | 1,914 (918 - 2,635) m |
| Mean distance from water level and range | 209.2 (10 - 650) m | 112 (30 - 250) m |
| Waterspread during nesting season | 8m | 14m |

RESULTS

The differences in survey results from 1976 and the present study are shown in Table 1. The discrepancy in total nests located for similar allocation of effort suggests a decline in the number of nests laid in the reservoir. The changes on the habitat between the years could not be quantified, but from Fig. 1, it is obvious that nesting sites used during 1976 were different from those utilised during 1994 nesting seasons. It is clear that the water spread during the nesting season had changed between the years. Nesting was observed only in the reservoir, Thuvanam and Amaravathi River during both surveys.

During the study period eight nests were located in the reservoir area between 26 February to 6 March, 1994; in the stream habitat, between 8 and 19 March, 1994. In the event of synchrony in nesting between reservoir and stream habitat, a reservoir nest would have equal probability of precedence by a stream nest as that of a stream nest preceding a reservoir nest. A combination of reservoir nests or stream nests would not be expected to arise. The nesting pattern in Amaravathi deviated significantly from this theoretical temporal order, $P < 0.005$ ($D = 0.75$; $n = 4$, Kolmogorov-Smirnov one sample test).

The inter-nest distances in the reservoir were significantly greater than those in stream habitat, $P < 0.005$ ($W_x = 35$; $m = 4$; $n = 5$, Wilcoxon Mann-Whitney test). The distance of the nest from the water in the reservoir were significantly greater than in stream habitat, $P < 0.005$ ($W_x = 45$; $m = 4$; $n = 6$, Wilcoxon Mann-Whitney test). The distance between the nest and the nearest deep pool was significantly greater in the reser-

voir than in stream habitat, $P < 0.005$ ($W_x = 45$; $m = 4$; $n = 6$, Wilcoxon Mann-Whitney test).

DISCUSSION

Comparison of survey results of Whitaker (1976, pers. comm.) with the present study suggests a possible decline in the nesting population in the reservoir area. In 1975, 14 nests were located in the reservoir; in 1983, 15 nests were located, suggesting little change in the nesting population in the area between the years (Davidar, 1983). The results from the present survey show decline in the nesting population from 1983. The increase in water spread from 8 m in 1976 to 14 m in 1994 (Table 1) submerged previous nest sites probably due to siltation in the reservoir. This may have resulted in the difference in nest site selection between the years (Fig. 1).

The temporal order of nesting in the reservoir and Thuvanam were not synchronous. Group synchrony can be used as an index of group cohesiveness (Jarman, 1974). Group cohesion was the least among the reservoir and stream habitat nesters.

The differences in the habitat parameters from the reservoir and Thuvanam nests suggests that nest site selection pattern of the crocodiles were different in these habitats. Large distance between nest sites and water level or nearest deep pool would impose greater costs on the animal at several stages of their breeding behaviour. The crocodiles would require to spend more time on land during nesting and parental care. Monitoring the nest from the deep pool would have been limited by the distance. The habitat parameters discussed above have direct implications on the

survival of hatchlings. Furthermore, lack of shallow water and cover for juveniles make them vulnerable to predation (Whitaker, 1979; Lang, 1987).

Aggregation of nests in stream habitat or scattered nesting in the reservoir may have resulted due to differences in the quality of the habitats. Abundance on a spatial scale in reptiles has been reported to be influenced by complexity of their habitat (Stamps, 1977). Thuvanam can be interpreted to possess greater complexity in contrast to the reservoir habitat. Therefore spacing of muggers may differ in the two habitats resulting in variation in their nesting pattern. However, Woodward et al. (1984) demonstrated that clumping of alligator nests was controlled by a factor closely related to nest site selection rather than complexity of habitat or nest site fidelity.

This study demonstrates that the choice of sub-optimal nesting sites by crocodiles and the shift in the spatial organisation of nests in the reservoir from 1976 may have resulted due to changes in the reservoir habitat. The inferences drawn in this paper were limited and weakened by low sample sizes. Similar studies in different reservoir habitats are required to assess mugger population in man-altered habitats. The study of nesting behaviour of crocodiles has been demonstrated to be an useful tool in assessing their habitat and population status.

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A CHROMOSOMAL CHECKLIST OF THE AMPHIBIANS OF INDIA

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ABSTRACT.- A list of the Indian amphibians for which data on chromosomal numbers are known are presented. The inventory includes 17 species (1 salamander, four caecilians and 12 anurans). The unresolved aspects of sex-chromosome mechanism and the importance of karyological studies for amphibian conservation in India are highlighted.

KEY WORDS.- Amphibians, karyotype, chromosome number, India.

At the recently concluded Biodiversity Conservation Prioritization CAMP for amphibians held at Bhubaneswar, India, in April, 1997, 206 species and subspecies of Indian amphibians were classified according to the basis of the new IUCN threat categories. In all, 85 per cent of taxa lack genetic database, with only a few species have their chromosomes confirmed with reliable techniques recently. While genetic information is essential for the success of any conservation programme, studies on the genetics of amphibians are of great theoretical interest for understanding transitional phylogenetic position, coexistence of primitive and bimodal karyotypes, low diploid numbers in higher forms, ill developed sex chromosomal mechanisms, giant lampbrush chromosomes in oocytes, and so on.

A checklist of the karyological records on diploid chromosomal numbers from amphibians in India is presented here in Table 1. The compilation has been made from the records by earlier workers (some of which are in the "grey literature") as well as personal findings of the author. A few publications may have been missed for the absence of a review on the subject. Chromosomal data on species from adjacent regions that also occur in India is presented in Table 2. Nomenclature followed is that proposed by Dubois (1992).

Among the Apoda, the karyotypes of only four species- *Ichthyophis beddomei*, *Uraeotyphlus narayani*, *U. menoni* and *Gegenophis carnosus*, have been recorded. This group exhibits the maximum number of chromosomal complements. The chromosomal numbers of the sole species of Caudata, *Tylototriton verrucosus*, has been recorded. Although the anurans have been

widely utilized for experimental and educational studies, only three bufonids, four microhylids, one rhacophorid and five ranids have been karyologically investigated. A noteworthy observation is that *Microhyla ornata* in India shows a higher chromosomal number ($2n = 26$) than in China ($2n = 24$).

An important aspect of the chromosomal studies is to identify the sex of chromosomal complements and in amphibians, this issue has been seen many interesting conflicts and remains unresolved. The earlier reports of morphologically identifiable heteromorphic sex chromosome pairs in some anurans are in need of reconfirmation. The paucity of genetic information in other amphibians makes the trends of amphibian evolution open to question.

Some amphibian geneticists have started utilizing newer techniques to resolve the issue by using banding studies and radioactive probing. The author is developing protein-enzyme variation profiles for conservation and systematics of amphibians, and believes that the time has come to conduct integrated research among various disciplines in order to save the genetic diversity of amphibians of India.

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BOLE GOWDA, B. N. 1948. The spermatogenesis of *Uperodon systoma*. Unpublished M. Sc. dissertation, Mysore University, Mysore.

TABLE 1: Checklist of cytologically investigated amphibians in India.

| Taxon | 2n | Reference |
|--|----|--|
| Family: Salamandridae | | |
| <i>Tylototriton verrucosus</i> Anderson, 1871 | 24 | Chatterjee & Majhi (1974) |
| Family: Ichthyophiidae | | |
| <i>Ichthyophis beddomei</i> Peters, 1879 | 42 | Seshachar (1936) |
| Family: Uraeotyphlidae | | |
| <i>Uraeotyphlus menoni</i> Annandale, 1913 | 36 | Seshachar (1939) |
| <i>U. narayani</i> Seshachar, 1939 | 36 | Seshachar (1939) |
| Family: Caeciliidae | | |
| <i>Gegenophis carnosus</i> (Beddome, 1870) | 30 | Seshachar (1944) |
| Family: Bufonidae | | |
| <i>Bufo himalayanus</i> Günther, 1894 | 22 | Chatterjee & Barik (1970) |
| <i>Bufo melanostictus</i> Schneider, 1799 | 22 | Natarajan (1953) |
| <i>Bufo stomaticus</i> Lütken, 1862 | 22 | Asana & Khardi (1937) |
| Family: Microhylidae | | |
| <i>Microhyla ornata</i> (Duméril & Bibron, 1841) | 26 | Sharma et al. (1977) |
| <i>Ramanella variegata</i> (Stoliczka, 1872) | 26 | Bai (1956) |
| <i>Uperodon globulosus</i> (Günther, 1864) | 26 | Chakrabarti (1978) |
| <i>Uperodon systoma</i> (Schneider, 1799) | 26 | Bole Gowda (1948) |
| Family: Rhacophoridae | | |
| <i>Polypedates maculatus</i> (Gray, 1834) | 26 | Natarajan (1958); Singh et al. (1970); Chakrabarti et al. (1983) |
| Family: Ranidae | | |
| <i>Euphlyctis cyanophlyctis</i> (Schneider, 1799) | 26 | Yadav & Pillai (1975) |
| <i>Euphlyctis hexadactylus</i> (Lesson, 1834) | 26 | Natarajan (1958) |
| <i>Hoplobatrachus tigerinus</i> (Daudin, 1803) | 26 | Natarajan (1958) |
| <i>Hoplobatrachus crassus</i> (Jerdon, 1853) | 26 | Yadav & Pillai (1975) |
| <i>Limnonectes limnocharis</i> (Gravenhorst, 1829) | 26 | Prakash (1988) |

TABLE 2: Checklist of cytologically investigated amphibians in adjacent countries that have been reported from India.

| Taxon | 2n | Reference |
|--|----|--|
| Family: Salamandridae | | |
| <i>Tylototriton verrucosus</i> Anderson, 1871 | 24 | Yang (1992) |
| Family: Microhylidae | | |
| <i>Microhyla heymonsi</i> Vogt, 1911 | 24 | Kuramoto & Yong (1992) |
| <i>Microhyla ornata</i> (Duméril & Bibron, 1841) | 24 | Zheng & Wu (1995) |
| <i>Kaloula pulchra</i> Gray, 1831 | 28 | Zheng & Wu (1993; 1995) |
| Family: Rhacophoridae | | |
| <i>Polypedates leucomystax</i> (Gravenhorst, 1829) | 26 | Kuramoto & Yong (1992); Matsui et al. (1986); Wu & Zeng (1993) |
| <i>Rhacophorus reinwardtii</i> (Schlegel, 1840) | 26 | Tan et al. (1989); Wu & Zeng (1993) |
| Family: Ranidae | | |
| <i>Limnonectes macrodon</i> (Duméril & Bibron, 1841) | 24 | Sugiri (1993) |
| <i>Occidozyga lima</i> (Gravenhorst, 1829) | 26 | Zhao et al. (1987) |
| <i>Rana chalconota</i> (Schlegel, 1837) | 26 | Kuramoto & Yong (1992) |
| <i>Rana livida</i> (Blyth, 1855) | 26 | Li & Wang (1985); Matsui et al. (1995) |
| Family: Pelobatidae | | |
| <i>Megophrys lateralis</i> (Anderson, 1871) | 26 | Wu (1987) |

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Sinonatrix, A New Genus for India

(with two text-figures)

In March 1997, we came across an interesting natricine while examining a collection of snakes made by the State Forest Department at Namdapha Tiger Reserve (Changlang District, Arunachal Pradesh, north-eastern India). The specimen is part of the Namdapha Tiger Reserve (Field Museum) collection, and is presently housed at the Range Office, Deban, Changlang District. It is unnumbered. Photographs of the specimen have been deposited at the Centre for Herpetology, Madras Crocodile Bank Trust, Mamallapuram 603 104, Tamil Nadu, India.

Table 1 provides important details on measurements and scalation of the specimen. Additional characters are presented below (see also Fig. 1 and 2). The pupil is round; the rostral broader than high; the nasal partially divided; the nostril directed upwards and outwards; the internasals narrowed anteriorly; the prefrontals broader than long; the frontal long, pointed posteriorly. The mental, anterior genials, posterior genials, infralabials, supralabials, internasals, prefrontals and the nasals, all have sensory tubercles. This feature suggests that the specimen is a sexually mature male. Based on the details, we identify the specimen as *Sinonatrix percarinata*, and report the species for the first time from India. We did not examine the maxillary teeth or the hemipenis. The ground colour of the ventrals of the preserved snake shows traces of red, which has not been reported in the species by Pope (1935) or Smith (1943).

The species was originally described as *Tropidonotus percarinatus* by Boulenger (1899) from Kuatun (= Guagun), Chogan Co., about 270 miles from Foochow (= Fuzhou), north-western Fokien (= Fujian) Province, China (see Zhao and Adler, 1993: 261), and allocated to the newly established genus *Sinonatrix* by Rossman and Eberle (1977). Maki's (1931) *Natrix suriki* was treated as a subspecies of *Sinonatrix percarinata* by Zhao and Jiang (1986), for which reason the western populations of the species must be re-



FIGURE 1: *Sinonatrix percarinata* (Boulenger, 1899). Uncatalogued specimen in the Field Museum of the Namdapha Tiger Reserve, Deban. Dorsal view of head.

TABLE 1: Data on measurements (in mm) and scalation of *Sinonatrix percarinata* (Boulenger, 1899) from Arunachal Pradesh, north-eastern India.

| Features | |
|--|--|
| Scales (keeled strongly, outer smooth) | 19:19:17 |
| Ventrals | 154 |
| Anal | 2 |
| Subcaudals (paired) | 72 |
| Supralabials (scales contacting orbit in brackets) | 9 (4 & 5) |
| Infralabials | 10 |
| Loreal (squarish) | 1 |
| Preocular | 1 |
| Postoculars | 3 (+1 postsubocular), 3 (+2 postsuboculars) |
| Temporals | 2 + 3 |
| Crossbands (body + tail) | 29 + 16 |
| Snout-vent length | 590 |
| Tail length | 175 |



FIGURE 2: *Sinonatrix percarinata* (Boulenger, 1899) from Arunachal Pradesh, north-eastern India. Ventral view of body.

ferred to the typical subspecies. Smith (1943) recorded *Sinonatrix percarinata* (Boulenger, 1899) from northern Myanmar (Gole Tutap and Suprabum), northern Thailand (Doi-Sutep), Vietnam (Tongking, Kontum in Annam), southern China (including Taiwan). The present record marginally extends the westernmost limit of its range.

We thank the following (in alphabetical order) for making this note possible: Ramana Athreya, Vidya Athreya, P. K. Biswas, J. Daltry, J. C. Daniel, H. V. Ghate, Jay Kadapatti, Anil Khaire, Neelinkumar Khaire, R. N. Naik, Kiran Shah and S. Thirunaavukarasu, and Edmond V. Malnate for confirming the identification of the specimen.

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Captive Breeding of the Saw-scaled Viper (*Echis carinatus*)

The saw-scaled viper (*Echis carinatus*) is widely distributed in the Indian subcontinent (Daniel, 1983). However, little information is available in the literature on the breeding biology of the species. The present study on a captive population of the species was carried out between August 1989 and July, 1994 at Sayaji Baug Zoo, Vadodara, Gujarat State, western India, to obtain new information on its breeding biology.



FIGURE 2: *Sinonatrix percarinata* (Boulenger, 1899) from Arunachal Pradesh, north-eastern India. Ventral view of body.

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TABLE 1: Measurements (cm) of breeding *Echis carinatus*

| Individuals | Snoutvent length | Tail length | Total body length |
|-------------|------------------|-------------|-------------------|
| M1* | 38.0 | 3.5 | 41.5 |
| F1* | 42.0 | 4.5 | 46.5 |
| M2** | 31.5 | 3.5 | 35.0 |
| F2** | 40.0 | 4.0 | 44.0 |

Two pairs of adult *Echis carinatus* (Table 1) were kept for study. They were captured from the outskirts of Vadodara city. The dimensions of the breeding enclosure were 50 x 25 x 25 cm. It was made of wood, with a sliding door on the top. The front had a transparent glass for observations. The cage was decorated with small rocks and pebbles and fine sand was spread on the bottom. Drinking water was provided in a small petri dish. The snakes were fed once a week on live lizards and mice (Table 2).

Both pairs were kept separately from August 1989 to July 1992 and March 1992 to July 1994. Both females bred continuously for three years, each producing live young each year, except one of the females which laid a capsule-shaped yellow ova without calcareous shell in the first year (1992).

Actual copulation was not observed, although females were noticed to stretch their bodies and raise their heads, while males crawled over them from the tail-side towards the head, to take up

TABLE 2: List of food offered to captive *Echis carinatus*

| No. | Food species | Weight (gm) |
|-----|----------------------------------|-------------|
| 1 | <i>Rattus rattus</i> (new born) | 5-12 |
| 2 | <i>Mus musculus</i> | 5-15 |
| 3 | <i>Hemidactylus flaviviridis</i> | 5-15 |
| 4 | <i>Hemidactylus brookii</i> | 5-12 |
| 5 | <i>Mabuya carinatus</i> | 5-10 |
| 6 | <i>Mabuya macularia</i> | 3-8 |
| 7 | <i>Calotes versicolor</i> | 5-15 |

presumably a copulatory position. This specific behaviour was observed five to eight times in the third and fourth weeks of the month of February, between 1800 and 2100 hours.

By the end of March, females took little interest in food, and by the end of April, the body showed a growing bulge, with the interscale skin at midbody visible. Both females went off food for about 15-20 days prior to giving birth. Live young were born in May and June, at night, three months after the courtship behaviour described. The clutch size of one was 10-19, that of the other, eight to 14. Measurements and weights of the neonates are in Table 3.

All neonates were covered with a transparent membrane. They emerged after a few seconds, but remained in the area until the umbilical cord was dry and brittle.

The presumed courtship behaviour observed in February supports the observation of Minton

TABLE 3: Dates of birth, brood size and measurements of captive born *Echis carinatus*. + two stillborn; ++ three stillborn; * number of unfertilised ova; ** eight live hatchlings and one ova.

| Individual | Date of birth | Brood size | Measurements | | | Mean weight |
|------------|---------------|------------|--------------------------------|--------------------------|--------------------------------|-------------|
| | | | Mean snout-vent length (range) | Mean tail length (range) | Mean total body length (range) | |
| F1 | 30 May 1990 | 10 | 11.02 (10.4-11.8) | 1.46 (1.3-1.7) | 12.48 (11.7-13.2) | — |
| | 19 May 1991 | 13++ | 11.76 (10.5-12.5) | 1.57 (1.3-1.9) | 13.33 (12.5-13.8) | 1.15 |
| | 1 June 1991 | 19++ | 9.95 (7.8-11.2) | 1.11 (1.0-1.3) | 11.06 (8.8-12.3) | 1.66 |
| F2 | 25 June 1992 | 11* | size of ova 1.50 x 0.90 | | | — |
| | 6 June 1993 | 8** | 10.73 (10.0-11.3) | 1.07 (1.0-1.2) | 11.80 (11.5-12.5) | — |
| | 30 May 1994 | 14 | 11.55 (9.2-12.5) | 1.42 (1.2-1.7) | 12.97 (10.5-13.7) | 1.35 |

(1966) regarding the timing of reproduction. The present study shows that gestation period in the species is about three months, and clutch size ranges between eight to 19, larger than the previous reports of four by Wall (1915) or three to 15 by Daniel (1983).

According to Whitaker (1978), females of *Echis carinatus* produce young ones twice a year in southern India. The same authority stated that it is unknown whether each female breeds every year. This study indicates that females can breed annually in western India.

I am grateful to V. A. Jadeja, Curator, Sayaji Baug Zoo, for providing facilities.

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First Record of *Tomopterna dobsonii* (Boulenger, 1882) (Anura: Ranidae) from Orissa, India

(with one text-figure)

Rana dobsonii Boulenger, 1882 was originally described from "Mangalore, south Canara, Mysore" (in Karnataka State, south-western India). The species is allied to *Tomopterna breviceps*, and due to this close relationship, Bhati and Shukla (1975) treated "*R.*" *dobsonii* as

a junior synonym of "*R.*" *breviceps*. However, these workers did not examine the type specimen itself, and based their decision on collections they made, which presumably included atypical specimens of *T. breviceps*. Pillai (1982) considered *T. dobsonii* to be distinct and Dutta (1986) provided additional notes on the systematic status of the species. The species has been recorded from Karnataka, Maharashtra, Tamil Nadu and Andhra Pradesh (Dutta, 1986; 1992; 1997).

On 18 May 1995, two examples (a mature male: 50 mm snout-vent length, SVL, and a gravid female: 51.0 mm SVL; SKD 95-11957 and ZSI 8888, respectively) of *Tomopterna dobsonii* were collected from inside Chandka Wildlife Sanctuary (20° 25'N; 85° 50'E), located ca. 20 km NW of Bhubaneswar City, Orissa, eastern India.

The record from Chandka is the first from Orissa. The closest record is from Wangasara, Waltair, Andhra Pradesh, about 600 km from Bhubaneswar, Orissa (Dutta, 1986). These specimens can be distinguished from two other sometimes sympatric congeners, *T. breviceps* and *T. rolandae*, by the following characters: smooth dorsum, rudimentary webbing between the toes (to the base of the first subarticular tubercle of toe IV), canthus rostralis distinct, tympanum small, dark pigmentation arranged in the form of patches on the dorsum absent, and a black streak laterally from the snout-tip to the tympanum. Additionally, *T. rolandae* differs from *T.*



FIGURE 1: *Tomopterna dobsonii* Boulenger, 1882 from Chandka, Orissa, India (ZSI 8888) in life.

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FIGURE 1: *Tomopterna dobsonii* Boulenger, 1882 from Chandka, Orissa, India (ZSI 8888) in life.

breviceps in having a tubercle at the tibio-tarsal articulation and rounded snout when viewed laterally.

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A Record of *Gehyra mutilata* (Wiegmann, 1835) from northern India (Sauria: Gekkonidae)

Gehyra mutilata (Wiegmann, 1835), as understood at present, is a widespread species of gekkonid (presumed natural distribution: south-western India and Sri Lanka, east to eastern China, Indo-Malaya, New Guinea and Oceania; Fisher, 1997; Smith, 1935: 106; Taylor, 1963: 781; Zhao and Adler, 1993) that is often a human commensal. The species has been reported from the Andaman and Nicobar Islands (De Rooij, 1915: 42; Biswas and Sanyal, 1980: 284). Records from the Indian mainland are from Cochin, 09° 58'N; 76° 17'E (Smith, 1935) and Kottayam,

09° 36'N; 76° 34'E (Soman, 1964), both in Kerala State, in south-western India. An example of this widespread species was found in the collection of Museum of Natural History, Louisiana State University, Baton Rouge, USA, which was collected by M. K. Ghorl on 8 August, 1971: LSU 24716, from Unnao (26° 48'N; 80° 43'E), Uttar Pradesh, northern India, is the first record of the species from northern India, and an extension of range of the species by ca. 1,800 km to the north. The specimen shows the following characteristics considered diagnostic for the species: paired enlarged supranasals that are in contact; enlarged scapulars, digits free, terminal phalanges of outer four toes slender, free, clawed, inner digit with tiny concealed claw, dorsal scales granular; tail depressed and pupil vertical.

The occurrence of *Gehyra mutilata* from northern India is suspected to be linked to human agency, as this species is thought to have increased its distribution in the recent past through accidental transport of these lizards and/or their eggs in baggage and boats (Taylor, 1963: 784). Records of the species are from Java (Church, 1962; Church and Lim, 1962), Borneo (Lloyd et al., 1968) and De Rooij (1915), Sri Lanka (De Rooij, 1915) and several archipelagos in the Pacific Basin (Fisher, 1997). The species has been introduced to México, southern United States, New Zealand (Bauer and Henle, 1994: 92) and more recently, to French Guyana (Ineich and Massary, 1997).

Thanks are due to Diana Reynolds, Division of Amphibians and Reptiles, Louisiana State University, for the loan of LSU 24716. A Fulbright Fellowship at the Museum of Comparative Zoology, Harvard University, supported my researches on the herpetology of Asia. Aaron Bauer verified the identity of LSU 24716 and Aaron Bauer, Ivan Ineich and Rom Whitaker read the manuscript, offering useful comments and citations.

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breviceps in having a tubercle at the tibio-tarsal articulation and rounded snout when viewed laterally.

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***Agama chernovi* is a Junior Synonym of *Stellio bochariensis* (Sauria: Agamidae)**

Agama chernovi was described by Ananjeva et al. (1981) from Gissar Ridge and other mountains in Central and South Tadjikistan. The authors compared their new species only with species they considered closely related, but did not discuss possible synonyms.

Nikolsky (1897: 159) described *Stellio bochariensis* from the same area ("Gissar in East Buchara"), which was redescribed by Nikolsky (1905: 52; 1915: 127). This species was subsequently synonymised by Terent'ev and Chernov (1949: 143).

Having compared an excellent picture of the type specimen of *Stellio bochariensis* (ZIL 7332) in Bedriaga (1909: Fig. II, 4, this specimen is hereby designated lectotype) with the photos of *Agama chernovi* (see Figs III and IV in the aforementioned article), no significant differences were found, the descriptions coinciding to the smallest detail. Both have seven to eight dorsal longitudinal rows of enlarged keeled, sharply pointed scales, three scale rings on each tail segment, flattened head and body, rounded section of tail. In my opinion, it follows that the correct name for this agamid lizard should be *Laudakia bochariensis* (Nikolsky, 1897), while *Agama chernovi*, *Laudakia chernovi* and *Stellio chernovi* (see Khabibullov, 1989) should be its junior synonyms.

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Diet of the Limbless Skink, *Barkudia insularis* Annandale 1917 (Sauria: Scincidae)

The limbless skink, *Barkudia insularis* Annandale, 1917, is a little known lizard, being secretive and rarely seen in the open (Smith, 1935). The isolated patches of forests over red loamy lateritic soil within the campus of Andhra University at Visakhapatnam (17° 40'N; 83° 10'E) support a population of this species, whose diet is here being reported.

Dietary studies were conducted through examination of gut contents of 79 lizards over three seasons. Lizards were sacrificed immediately after capture and volume of food estimated through displacement of water in a graduated microtube (Subba Rao, 1967). The results (Table 1) show that termites comprise a large proportion of its diet throughout the year, although ground beetles (Coleoptera) are also ingested. However, a significant portion of the stomach contents that could not be identified, is suspected to be the remains of soft-bodied prey (such as earthworms

TABLE 1: Analysis of stomach contents by volumetric estimation of *Barkudia insularis* from Visakhapatnam, south-eastern India. Unidentified and trace items in stomach samples unlisted.

| Season | Isoptera | Coleoptera |
|-------------------------|----------|------------|
| Winter (n=21) | | |
| Percentage volume | 52.38 | 23.81 |
| Frequency of occurrence | 11 | 5 |
| Summer (n=24) | | |
| Percentage volume | 45.83 | 38.10 |
| Frequency of occurrence | 11 | 8 |
| Monsoons (n=34) | | |
| Percentage volume | 85.29 | 61.76 |
| Frequency of occurrence | 29 | 21 |
| Annual (n=79) | | |
| Percentage volume | 64.56 | 43.04 |
| Frequency of occurrence | 51 | 34 |
| Mean | 69.69 | 50.61 |
| ± SD | 18.02 | 14.80 |

and insect larvae and pupae). In this third category were remains of spiders and scorpions.

Soil particles found could be the result of accidental ingestion. Total stomach volume ranged between 0.021-0.300 ml. It was assumed that feeding peaked during and before dusk.

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Evaluation of Sea Turtle Nesting Beaches for Promoting Participatory Conservation at Sundervan Beyt Dwarka, India

Evaluation of sea turtle nesting beaches was undertaken at Sundervan Beyt Dwarka and within the vicinity of Dunny Point, in the Gulf of Kachchh, Gujarat State, India, with the following objectives: 1. identification of nesting beaches; 2. identification of nesting sea turtles; 3. determination of the "wow" factor to sell conservation education with reference to sea turtles; and 4. development of a conservation strategy for implementation.

Methods included: 1. preliminary beach survey; 2. day and night surveys of identified beaches during high tide; and 3. interviews with the local people.

Findings of the survey:

1. According to local information from ferry and trawl operators, two species of sea turtles are known to nest at Beyt Dwarka, the olive ridley (*Lepidochelys olivacea*) and the green (*Chelonia mydas*). A carapace of a leatherback sea turtle (*Dermochelys coriacea*) was found, but nesting in this species appears doubtful. It is possible that hawksbill sea turtles (*Eretmochelys imbricata*) may also be found off the coast.

2. During surveys of the beach near Dunny Point, a number of bone fragments, including pieces of plastron, carapace and skull of a green turtle was found near Hanuman Dandi.

3. Some old and new signs of nesting were observed. Three favourable nesting areas were identified. The first was close to Dunny Point, the second near Hanuman Dandi, the third south-west of Hanuman Dandi.

4. Typical turtle crawl tracks were observed on all the mentioned beaches. Two different sets of tracks were found. Track widths at Dunny Point averaged between 33-36 cm, while tracks seen in the vicinity of Hanuman Dandi measured about 110 cm. It appears evident that the olive ridley and the green are the species involved.

5. The ecological characteristics of beaches (sandy/muddy/rocky) were recorded for their interpretive value, for the purpose of initiating sea

turtle conservation education programme at Dunny Point. At places, marine organisms, from invertebrates (including corals) to higher forms, were accessible. The shore bird diversity was found to be rich.

6. Jackals (*Canis aureus*) and wild boar (*Sus scrofa*) were the primary egg predators at most beaches, and a number of depredated nests were seen. This was also emphasized to the local people. While there appeared to be no poaching of eggs for human consumption, sea turtle eggs were found to be used as horse feed. The contents of eggs were mixed with jaggery (brown sugar, locally called 'gur'), and fed to cart-pulling horses, supposedly to make them strong.

7. Meetings were held with local fisherfolk, customs officials, naval personnel and former local village and Panchayat heads, to seek information on sea turtles and their opinion on conservation. This exercise reveals a common consensus for sea turtle conservation. Some of the suggestions included providing in situ protection, with the aid of barbed wire fencing at nesting beaches to discourage jackals and wild boar, or even wire mesh cover over individual nests. Plans for hatchery rearing was also discussed.

8. Sundervan Beyt Dwarka already has an on-going marine nature camp programme as part of overall environmental education thrust. These camps cater to a wide range of target groups, such as school children, nature club members, as well as family groups. The value of this particular site has been recognised as a potential EE facility to focus on sea turtle conservation and incorporate conservation education concepts to the existing marine camp programmes. Steps in this direction have already been made on a trial basis. In this regard, an introduction to the fascinating world of sea turtles has become part of the camp curriculum. Campers are taken for turtle walks to nesting beaches and some of them sight turtles off the coast. Such first hand experiences help build a concern for sea turtles and related issues and generate awareness.

Beyt Dwarka can be recognised as an environmental education facility with special reference to sea turtle conservation education programmes. The outdoor camping arrangement at Dunny Point is located close to nesting

beaches. Fortunately, the camping activities commence during the nesting seasons and participants are organized into smaller groups to patrol the nesting beaches in an attempt to ward off predators such as jackals and wild boars. A demonstration hatchery is planned for the next camping season, where campers will be trained to pinpoint nests and translocate eggs. This will attempt to organize community participation. Meanwhile, sea turtle conservation education material, such as brochures and posters, are being designed for communication geared towards awareness and action.

Without local support at Beyt Dwarka, this survey would not have been possible. Hemuba, a village head and former Panchayat leader, who is also the caretaker of Sundervan Beyt Dwarka and his son Ganshyam provided information on sea turtles and nesting habitats at Beyt. Anvar, the local ferry and fisherman provided vital identification clues to sea turtle species. An enthusiastic band of volunteers from Bhumata helped nightly beach walks. This survey was supported by A. J. Urfi, Sundervan- Nature Discovery Centre, Ahmedabad. Field support at Dunny Point was provided by Rajendrasinh Jadeja.

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Captive Breeding of *Varanus salvator andamanensis* Deraniyagala, 1944

Varanus salvator andamanensis Deraniyagala, 1944, the Andaman water monitor, is endemic to the Andaman islands. The habitat range of this subspecies includes wet evergreen forests, dried flat and wetlands and littoral forests. They also inhabit mangroves and small remote islands, including South Sentinel, which is only 1.61 sq km in area. Lizards on this particular island attain

large sizes, males often exceeding 2.5 m in total body length (H. Andrews, pers. comm.).

There is little information of the biology of the species on these islands. Hatchlings are noticed during March and April, and the lizard is known to feed on eggs of sea turtles and crocodiles, as well as crabs on mangrove marshes at low tide. They have been sighted swimming across mangrove creeks, and even in coral reefs. Although commonly hunted by tribals and settlers for meat, there is no trade in skins, and population declines are not suspected.

The first captive breeding effort for the Andaman Island subspecies was taken up at the Haddo Mini Zoo, Port Blair, Andaman Islands. In 1995, the zoo acquired two female lizards from the Shoalbay area and Mini Bay, both in the South Andamans, and in 1996, a male from the Mayabunder area in the Middle Andamans. All three lizards were wild caught, and no initial measurements are available. On 30 April, 1997, they were measured. The male was 148 cm in total body length (TBL), 71 cm in snout-vent length (SVL) and weighed 9.0 kg. The females measured 133 and 104 cm (TBL), 61 and 56 cm (SVL) and weighed 5.75 and 3.75 kg, respectively. Both females had tail tips missing. One male measuring over 2 m (TBL) from South Sentinel Island, was added to the breeding group in March, 1997.

All animals were housed in an enclosure measuring 13.1 x 9 m, with a wall height of 1.85 m. The substrate is sand and grey soil that is typical of these islands. The enclosure is landscaped with a tree, bamboo clumps, dead logs and shrubs, and has a central pond measuring 4.2 x 4 m and is 0.32 m deep. The lizards are fed chopped beef and chicken ad libitum.

On 8 August, 1996, two eggs were noticed on the soil surface and were found missing the next day, and were presumed eaten either by rats or the monitors themselves. It was unclear which female produced these eggs and there was no evidence of further eggs or nests in the enclosure. On 4 April, 1997, however, four hatchlings were found within the enclosure. By the end of the month, three more were observed, in addition to the discovery of a dead hatchling. It was not possible to determine if these hatchlings were

part of the clutch found on the soil surface. These were estimated to be at least 10 days old, all showing dried and closed umbilical scars and none had an egg tooth. The incubation period for this clutch- seven months, is within the known range (seven to 10 months) reported from the mainland by Andrews (1995) and Andrews and Gaulke (1990). On 30 April, 1997, the hatchlings (n = 7) measured 30-33.8 (mean 30.1) cm (TBL), 13.4-15.0 (mean 14.2) cm (SVL) and weighed 29.5-34.0 (mean 31.4) gm. The background colour of these hatchlings was grey, the rings around the body composed of orange spots, unlike in populations from mainland India, where the spots are yellow. The markings on the head are also orange, whereas lizards from the Indian mainland have yellow cephalic markings.

Seven hatchlings are being maintained in a glass tank 50 x 30 x 30 cm. They are fed chopped fish and beef.

I wish to thank Harry V. Andrews of the Madras Crocodile Bank Trust for his guidance, and the staff of the Haddo Mini Zoo, particularly K. Mohammed Ali, Veterinary Compounder, for looking after the lizards. Smti Zainaba is acknowledged for typing the manuscript.

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Notes on Reproduction in *Philautus annandalii* in Sikkim

Philautus annandalii (Boulenger, 1906) is one of the most conspicuous species of frog in the Eastern Himalayas. Its breeding season is restricted to June-August, during which the distinctive "tak-tak" call of the males can be heard. Aspects of its natural history have been described by Daniel (1962).

On 20 June, 1997, a male and a female were collected at 1900 hours after a heavy shower from a bush in the vicinity of Soreng Police Station, West Sikkim, eastern India. They were kept in a transparent plastic jar for observations. At 1950 hours, a second male was added. The colour of the dorsum of all three frogs were observed to be yellow. At 2000 hours, axillary amplexus was observed within the jar. Within 30 minutes, the colouration of the frogs in amplexus turned blackish, while the solitary male remained yellow. On 22 June, 1997, at 0800 hours, the female started laying eggs. A little amount of water was added to the jar to increase humidity. A total of 13 eggs were laid between 0800-0835 hours. Eggs were unpigmented, measuring ca. 1 mm in average diameter, and were covered with a gelatinous covering, which, after hydration, swelled up, and were scattered singly at the bottom of the jar. After egg laying, the paired frogs separated and reverted back to their original colour.

In all, 32 clutches of eggs were detected in the wild on 23 June, 1997, which were either within crevices on hill slopes or within cracks in walls. Two clutches were discovered in exposed situations, one on the surface of a wall, the other on

TABLE 1: Data on clutch and nests of *Philautus annandalii* from Soreng, Sikkim, India.

| Microhabitat | Clutch size | Substrate type |
|-----------------------|-------------|-----------------|
| crevice of wall | 27 | moist soil |
| crevice of wall | 19 | moist soil |
| crevice on hill slope | 23 | moist soil |
| surface of hill slope | 18 | damp vegetation |
| surface of wall | 20 | damp vegetation |

vegetation over rocks on a hill slope; in both cases, the eggs were exposed to direct sunlight. Wild eggs were also unpigmented, and laid in a clump, and clutch size ($n = 5$) varied between 18 and 27 (Table 1). The unpigmented eggs (i.e., eggs lacking an animal pole) and the discovery of a majority of wild clutches in moist substrate, away from direct sunlight, suggests that the species utilizes concealed habitats for laying eggs. The discovery of such sites, that are nowhere near waterbodies suggests that *Philautus annandalii* exhibits reproductive mode 16 (of Salthe and Duellman, 1973), and the larval stages are likely to show direct development, as also reported for other species of the genus (see Dring, 1987; Alcala and Brown, 1982).

I thank Samir Banerjee for assistance during these observations.

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Ahaetulla nasuta Feeding on Tadpoles

The diet of the common vine snake (*Ahaetulla nasuta*) consists mainly of small mammals, birds, lizards, frogs, and occasionally, other snakes (Daniel, 1983; De Silva, 1990; Whitaker, 1978). In captivity, it has been known to feed on skinks, frogs and mice, picking them up from the ground if necessary (Samraat Pawar, pers. comm.). It has also been reported to catch fish (Whitaker, 1978).

In the second week of July, 1997, a field trip was made to Castle Rock, on the Goa-Karnataka border. Although the area is covered with semi-evergreen forest, the immediate surroundings of Castle Rock village are mostly scrubby and open. The rains had started and many frogs were breeding. On the morning of 14 July, 1997, we were walking on a nature trail in the scrub forest when we saw an *Ahaetulla nasuta*, over 60 cm in length, staring attentively at a small rock on the ground. It was resting on a *Carvia* stem beside a path, with the anterior portion of its body thrown into a sigmoid curve, and slowly moving towards the rock. When its head was 15-20 cm away from the rock, it struck at it and caught a tadpole that was in a wet depression on the rock and swallowed it. After five minutes, it caught another, in a similar fashion. Before the snake swallowed this one, we caught the snake and examined the tadpole. Both the tadpoles were about 25 mm in total body length. These tadpoles were not held in the mouth till they ceased struggling, as in the case of other larger prey (Daniel, 1983; Samraat Pawar, pers. comm.), but swallowed immediately.

The tadpoles have not been identified but were probably those of *Indirana leithii*, a common frog in the area. The red laterite of Castle Rock is rough, with numerous depressions separated by sharp edges to the rocks. The tadpoles were abundant in such depressions. Several developmental stages were noticeable, although a majority had developed hind limbs. They hopped when disturbed and took refuge in the cracks and depressions in the rock. Both tadpoles eaten by the vine snake showed hind limbs.

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This appears to be the first record of *Ahaetulla nasuta* predation on larval amphibians. Although this food type is only available seasonally, considering the abundance of these tadpoles at the locality, may constitute a major part of the diet of the snake during the monsoons. Also, the precision of the strikes of the snake is noteworthy, as each strike was directly aimed at the rock surface, and its binocular vision may play a vital role for such predatory behaviour.

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Sexual Dimorphism in *Kachuga tecta* and *K. smithii* (Testudines: Bataguridae) in Jammu, India

Among turtles males and females often differ in colouration, maturity size, shell proportions and other features (Agarwal et al., 1986; Aufenberg and Khan, 1991; Cagle, 1944; Das, 1985; Gupta, 1979; McCoy, 1968; Minton, 1966; Moll, 1987; Viosca, 1933; Graham, 1970; Verma, 1992). The reasons for these differences are however, poorly understood. Presumably, in some species, it may reflect factors important in social interaction and re-

production, and species showing little or no size dimorphism, may have evolutionary/environmental constraints on the development of marked size differences (Bury, 1979).

Darwin (1871) envisioned sexual size differences as a result of sexual selection, as selective force, unrelated to natural selection (Arnold, 1983) in which characters that enhance access of one sex to the other, usually males to females, are favoured. On the contrary, other workers (including Berry and Shine, 1980; Fitch, 1981; Shine, 1979 and Stamps, 1983) believe that sexual size dimorphism (SSD) is a result of ecological forces or natural selection due to differential interactions of each sex with its environment. Gibbons and Lovich (1990) were of the view that even local populations of turtles exhibit different degrees of SSD varying through time.

Data on the sexual dimorphism of freshwater turtles from India are fragmentary, based on some species from southern and central India. *Kachuga tecta* (Gray) and *K. smithii* (Gray) of the family Bataguridae, are the most abundant freshwater batagurid turtles in Jammu (Verma, 1992) in northern India. Both of these species are little known, and a complete account on sexual dimorphism in these turtles is lacking. This study was undertaken to generate information on sexual dimorphism in these turtles from a lotic habitat in Jammu.

Turtles were collected between 1988 to 1992, throughout the year, except during hibernation (November to February), by methods described elsewhere (Duda et al., 1993) from the Gho-Manhasan stream (74° 40'E; 32° 38'N), at an elevation of 302.6 m above sea level and situated circa 18 km north-west of Jammu city. Males were sexed by external characters (e.g., their relatively longer tail and bright colouration). All linear measurements of animals were recorded to the nearest mm using a flexible tape (for the shell) or with the help of dividers (the tail, from anus to tip). Most turtles were released after measurement, and only a few were taken to the laboratory for photography and identification. Sexual size dimorphism (SSD) in turtles was calculated using Size Dimorphism Index (SDI) after Lovich and Gibbons (1992):

TABLE 1: Morphological characteristics differentiating the two sexes in *Kachuga tecta* and *K. smithii*.

| Characteristics | <i>Kachuga tecta</i> | | <i>Kachuga smithii</i> | |
|---------------------------------|---|---|---|---|
| | Male | Female | Male | Female |
| Relative size and habitus | Smaller. Size 100 (range 60-140) | Larger. Size 140 (range 100-180) | Smaller. Size 93 (range 56 - 130) | Larger. Size 160.5 (range 102 - 219) |
| Shell form | Concave plastron. Mid-vertebral streak more pronounced. Pronounced humping on shell | Flat plastron. Vertebral streak and humping on shell less pronounced. | Concave plastron | Flat plastron |
| Colouration | Blanch-green carapace and eosin red plastron | Brown carapace and straw-yellow plastron | Light green carapace and pale yellow plastron | Brownish carapace, pale-yellow plastron |
| Tail length | Relatively longer and thicker | Relatively shorter | Relatively longer and thicker | Relatively shorter |
| Mean tail-plastron length ratio | 0.20 | 0.08 | 0.21 | 0.09 |

TABLE 2: The relative size of tail in relation to the plastron in males of *Kachuga tecta* and *K. smithii*.

| Size classes | <i>Kachuga tecta</i> | | | <i>Kachuga smithii</i> | | |
|--------------|---------------------------------------|-----------------------------------|---|---------------------------------------|-----------------------------------|---|
| | Plastron length Range (mean); N | Tail length Range (mean); N | Tail length/Plastron length ratio | Plastron length Range (mean); N | Tail length Range (mean); N | Tail length/Plastron length ratio |
| 1 | 60-80 (69.25) 4 | 12-17 (14.00) 4 | 0.20 | 50-70 (62.00) 5 | 12-19 (13.80) 5 | 0.22 |
| 2 | 80-100 (88.18) 27 | 18-23 (19.74) 27 | 0.22 | 70-90 (82.44) 9 | 13-21 (12.55) 9 | 0.15 |
| 3 | 100-120 (113.00) 3 | 21-26 (24.00) 3 | 0.21 | 90-110 (98.00) 15 | 15-24 (22.93) 15 | 0.23 |
| 4 | 120-140 (137.50) 2 | 28-30 (29.00) 2 | 0.21 | 110-130 (120.00) 5 | 22-25 (23.20) 5 | 0.19 |

$$S.D.I. = \frac{\text{Size of largest sex}}{\text{Size of smallest sex}} - 1$$

Kachuga tecta males show a blanch-green carapace and an eosin-red plastron, while females have a brown carapace and straw-yellow plastron. The mid-vertebral, a deep eosin-red streak is more pronounced in males. Males display a slightly concave plastron transversely and there is more pronounced humping of the dorsal region, whereas the females show a relatively flat plastron. Females were also found to be larger than males (Table 1). Additionally, the tail in males is relatively longer than in females, the ratio of tail length to plastron length in males averaging 0.20 (range 0.20-0.22) compared to 0.08 (range 0.06-0.10) in females (Table 2). Agarwal et al. (1986) reported white bands on tail

of males and yellow bands on that of the females. Additionally, darker carapace and a red iris was also shown by the males. Moll (1987), based on a sample from northern India, had reported that colouration in both sexes of *K. tecta* is similar, although, females are generally much larger (147 mm max-PL) than males (63 mm max-PL) and males differ from females by having a longer and thicker tail in which the vent opens beyond the carapacial rim.

In *Kachuga smithii*, females are much larger than the males (Table 1). The carapace is light green in males and brownish in females. Additionally, the dorsal surface of the carapace in females is smooth, whereas in males, it has a decidedly gritty or sandy feel. The tail of males is much larger and thicker at the base than in the

females. The ratio of tail-length to plastron-length in males averaged 0.21 (0.15-0.23) in males and 0.09 (0.007- 0.12) in females (Table 2). Minton (1966) also reported that the tail of male *K. smithii* projects free for about 10 percent of the carapace length, whereas that of the female is about 5 percent.

A perusal of Table 1 reveals that males of *Kachuga tecta* and *K. smithii* differ from the females by having a relatively smaller body size, a slightly concave plastron (more so in *K. tecta*), a larger, thicker, prehensile tail and a more colourful shell. The ratio between tail-length and plastron-length (PL) in the males of both the species is nearly twice that observed in the females. These findings are consistent with the reports of Aggarwal et al. (1986); Gupta (1979), Minton (1966) and Moll (1987).

Of all the tabulated male-female differences in *Kachuga tecta* and *K. smithii*, body size is the most variable and as such the least dependable indicator of the sex. However, in combination with bright colouration, a relatively larger tail and plastral concavity, the sex can be dependably assumed to be that of a male. The plastral concavity in males is however, not unusual to these turtles, as this adaptation of varying magnitude is prevalent among male members of a number of hardshelled turtles, including aquatic, semi-aquatic and terrestrial forms, such as *Clemmys marmorata*, *Terrapene carolina*, *Chrysemys insculpta*, *Terrapene ornata* and the aquatic form *Emydoidea blandingii* all belonging to the family Emydidae (Ernst and Barbour, 1972).

The sexual dimorphism indices calculated for the turtles under present investigations are + 0.40 for *Kachuga tecta* and + 0.72 for *K. smithii* indicating thereby, that the females of both these turtle forms are always larger than their male counterparts showing a high degree of size differences between the two sexes of these species.

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A Note on Reproduction in *Calotes calotes* at Anaikatty, Western Ghats

The southern green calotes, *Calotes calotes*, is a slender, long-tailed arboreal agamid that is widely distributed in Sri Lanka and southern

peninsular India (Daniel, 1983). This note presents some observations on nesting of *C. calotes* at the Coimbatore Zoological Park at Anaikatty (76° 45'E; 11° 06'N) in the Western Ghats of the Nilgiri Biosphere Reserve, Tamil Nadu State, southern India. The site lies in the catchment area in the Kodungarai River and part of the Perianaickempalayam Reserve Forest, between altitudes 600-700 m above mean sea level. The average annual rainfall at the locality is below 1,000 mm. While dense thorn forests dominate the reserve forest area, the zoo site is barren, except for thickets of *Dendrocalamus strictus*, *Jatropha* sp., *Pongamia pinnata* and *Ziziphus mauritiana*, along the dry nullahs.

During our field work between January and August, 1997 (approximately 60 h of observation), a total of 15 sightings of the lizard was made, of which three sightings refer to nesting animals (on 6 May, 13 June and 2 July). The nesting sites were in moist sandy microhabitats, in the shade.

On 2 July, a female was found excavating a nest, frequently resting for about 30 seconds at a time, during which the lizard appeared to scan the surroundings. Both the fore and hind limbs were used for digging, and the entire process of nesting and egg-laying took 1 h and 40 min. The female left the nest after covering the eggs with loose sand. This nest was 7 cm deep.

All three nests were excavated and the mean measurements of eggs (length and width) were 11.9 and 8.4 mm, respectively. The first two clutches were found inundated and the third clutch, when examined on the 45th day, contained dead embryos. We attribute the embryonic deaths to water-logging and low temperatures. The known clutch size in this species is six to eight eggs (Kannan and Bhupathy, 1996) and six to 12 eggs (Smith, 1935). In this study, the mean clutch size was found to be 10.31 (10, 10 and 11). Available records on the breeding biology of *Calotes calotes* reveal that the species breeds during April, May and September (Karthikeyan, 1993; Prasad and Jayanth, 1991; Murthy, 1985), which broadly coincides with our observations, between May and July.

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First Record of *Occidozyga lima* (Gravenhorst, 1829) from Bangladesh

The distribution of *Occidozyga lima* (Gravenhorst, 1829) is generally given as India to eastern China, and south to Indochina and the Malay Peninsula, Java and its associated islands (Berry, 1975: 61; Frost, 1985: 465; Zhao and Adler, 1993: 137; van Kampen, 1923: 232). Inger (1966: 367) considered the taxon to be transitional element, probably of Indochinese affini-

ties, in the fauna of Indo-Malaya. The record from the Indian subcontinent is however, unclear. Günther (1864: 401) mentioned that, besides its distribution in eastern and south-eastern Asia, the species is "said to occur also in Bengal", which is suspected to be the source of the record from West Bengal in Dutta (1992; 1997: 149). After the partition of India in 1947, the lower Bengal region was divided into an eastern sector (East Pakistan, after 1971, renamed Bangladesh) and a western sector (West Bengal State of India). There are therefore, no specific records of *O. lima* from either of the two countries (Bangladesh or India), and the taxon has not been specifically recorded from Bangladesh (see Chowdhury, 1996; Husain and Sarkar, 1978; Khan 1982: 30-31). Taylor (1962: 350) ignored the record from the Indian subcontinent.

On 18 August, 1997, at 2100 hours, a group of several adults and over a dozen frog metamorphs were observed within a 5 m area in a perennial body of water, 6-7 sq m in area and 2-3 m deep in Whykeong village (GPS reading 21° 06.879'; 92° 11.661'; elevation 10 m above msl), Teknaf Police Station, Cox's Bazar District, Bangladesh. Two examples, an adult female and a metamorph, were collected. The collection locality lies within a forest village, at which site existed a dipterocarp-dominated semi-evergreen forest about 30 years ago. The waterbody was at the slope of a ca. 60 m hillock. Aquatic macrophytes identified at the pond included *Clerodendron infortunatum*, *Enhydra* cf. *fluctuans*, *Nymphaea nouchali*, *Colocasia* and *Polygonum*. At least two frogs were heard calling, suggestive of breeding activities. The call can be syllablized as "khekkko-khekkko....", repeated four to six times. One female had a ca. 30 mm long earthworm inside its mouth.

These were identified as *Occidozyga lima* for the following characteristics: tympanum concealed; vomerine teeth absent; small body size (22 mm in the adult female); fingers with vestiges of webbing; toes completely webbed, skin with tubercles throughout (including on palms and soles); and short snout. The specimens will be deposited in the collection of the Zoological Survey of India, Calcutta, India. The northern part of the Teknaf Peninsula is contiguous with the

Arakan Range, the Naaf River and an estuary delimiting the border of Bangladesh from Myanmar, from where *Occidozyga lima* has been recorded.

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A LITTLE BOOK OF MONITOR LIZARDS by Daniel Bennett 1995. Viper Press, Aberdeen. Available from: Viper Press, P.O. Box 10087, Aberdeen AB2 2GT, Scotland, Great Britain. 208 pp. ISBN 0952663201. Price: US\$ 30.00.

This guide to the world's monitor lizards is no little book. Eight years in the making, with a lot of travel and effort, Bennett got this brilliant and useful guide out, which is a real welcome.

A Little Book of Monitor Lizards is a guide to the monitor lizards of the world and their care in captivity. It has 18 colour plates illustrating 129 pictures of virtually every species of monitors, besides numerous black and white plate photos illustrating species as well as climate charts and regional distribution maps for 46 species.

The book starts with an introduction to the Family Varanidae and goes on to the history of monitor lizard taxonomy, population densities, behaviour, reproduction and trade. Species descriptions go along with a distributional map with detailed descriptions that include habits and behaviour, habitat and ecology. A considerable amount of care has been taken to include breeding biology and thermoregulation for several of the species from published data. Descriptions of hatchlings and colouration have been incorpo-

rated where possible, which is a useful tool for field herpetologists.

This interesting book tails off into the two chapters explaining about keeping these lizards in captivity, captive breeding and monitoring. Details include housing, heating, substrate, light and humidity, besides diet and diseases. The captive breeding chapter incorporates techniques for sexing monitors, egg incubation and temperature-dependent sex determination in these animals. The last chapter deals with the future of monitors, including their conservation problems and economic importance.

Bennett has taken a lot of effort to review an impressive amount of literature and the bibliography section of the *Little Book* lists into 1,064 references!

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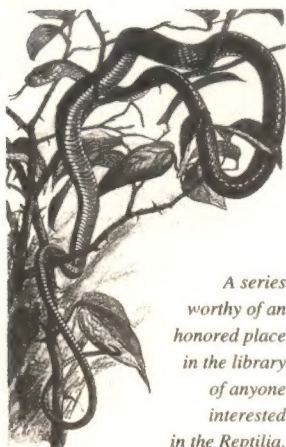
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The Cardiovascular System: The Heart, by Anthony Farrell, A. K. Gamperl, and the late E. T. B. Francis; *Cardiac Shunting*, by James Hicks. *The Hepatic System: The Liver*, by Fenton Schaffner. *The Spleen*: by Yasukazu Tanaka.

This volume summarizes the major organs situated in the coelomic space, organs that function in metabolism or are involved with endocrine and reproductive activities. As such, it will be of interest to zoologists and herpetologists but also to veterinarians and herpetoculturists. Each chapter includes descriptive morphology combined with discussions of function and of ecological and evolutionary relationships.

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